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(54) Partial line turnaround device for printers.

(57) A printer is provided with a partial line turnaround device. The printer has means (234, 235) to move a form or document past a print line, and a print assembly (35) incorporating a plurality of print wires arranged in print head groups, each group comprising a predetermined number of print wires. If, as an example, the print assembly has two, four, six, or eight print heads, each can accommodate eight wires in the embodiment described. The print wires are arranged in a slanted serrated pattern and provision is made herein to insure that the print heads move at least far enough to print their assigned character locations prior to the performance of any turnaround in individual lines being printed. Tables are accessed in conjunction with a microprocessor (210), the tables indicating the optimum turnaround situations for the different print head configurations. An emitter (236) is provided in the printer unit which has character emitters, margin emitters and other emitters as well as turnaround emitters that are used in conjunction with the turnaround decision making process to reverse direction of the print head assembly in order to start printing of a new line.

EP 0 027 564 A2

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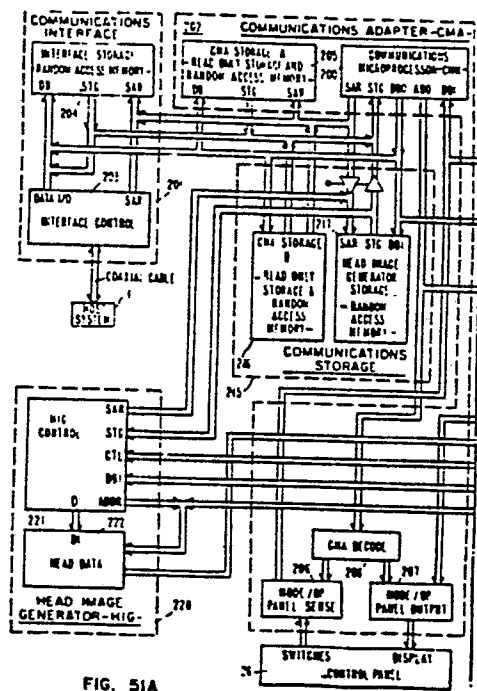


FIG. 51A

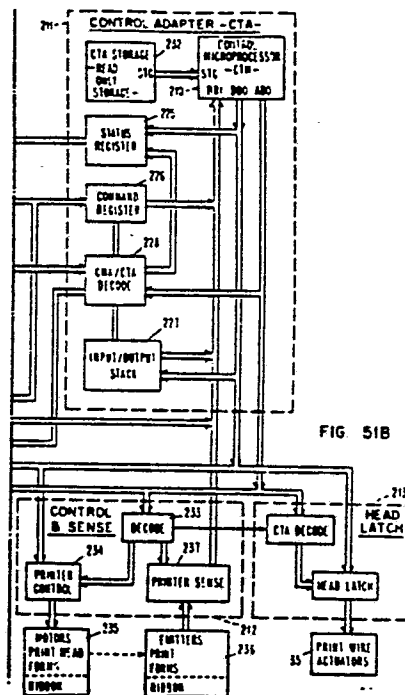


FIG. 51B

PARTIAL LINE TURNAROUND DEVICE FOR PRINTERS

Technical field to which the invention
relates

5 This invention relates to partial line turnaround device for
printers and particularly for printers that operate at
relatively high speeds in response to data signals from a
data source, such as a host data processing system. More
particularly, the invention relates to provision of decision-
making facilities in the printer subsystem to increase
10 printing throughput.

Relevant background art

In previous printer systems or subsystems that receive data
from a host system, printing throughput has been improved by
analyzing the lines of data as they are presented to the
15 printer to determine the relative line lengths and locations
with respect to one another with the objective of printing
the lines in the fastest manner possible. In some cases,
printer units are provided with a bidirectional printing
capability which enables them to print lines either from
20 left to right or right to left on a form or document inser-
ted in the printer. In such a printer, the lookahead analysis
of lines to be printed enables the printer to move the print
head to the closest end of the next succeeding line of print
thus saving time during printing operations.

25 Such a bi-directional printing operation with line lookahead
is described in US-A 3,964,994 (E.G. Brooks et al) published
January 2, 1973. This IBM patent describes a serial printer
having a print element capable of printing in both direct-
ions across a print form. A succeeding line of print on the
30 form is pre-analyzed to determine the end position of this
line of print. The print element is moved from the last
position printed on the preceding line to the closer end

position of the succeeding line so that printing of the succeeding line may take place beginning from said closer end print position.

Assessment of the background art

- 5 Most of the printer units have been based on conventional wire images. That is, considering a wire matrix type of printer, the data is presented to the printer and is actually printed on the document in a sequence of vertical columns of wire dots laid down by actuation of print wires in the
- 10 printer. When nonconventional print wire images are used, the wire images in the printer unit do not conform to the conventional geometrics, and it is necessary to consider many additional factors in the lookahead analysis.

Disclosure of the invention

- 15 In accordance with the present invention, there is provided a printer unit incorporated in a printer subsystem which receives character wire image information from a host data processing system. The printer unit is provided with a plurality of print heads, each having a predetermined number
- 20 of print wires. In a typical example, the printer unit may have 2, 4, 6, or 8 print heads each with 8 individual print wires and print wire actuators. The printer unit has a forms feed assembly, a ribbon drive assembly, and a print assembly mounting the print heads and arranged to drive the
- 25 print heads along a print line of a document to be printed. The print heads are ordinarily positioned in a home or ramp location, and when printing is required, are moved through a left margin toward a right margin area. In the preferred embodiment described herein, the print wires in each print
- 30 head group are arranged in a slanted serrated wire image pattern and it is important that each print head move completely through its assigned printing area along the print line before any turnaround action is performed in the printer. Each head is assigned the task of printing a given

quantity of characters depending upon how many print heads are in the printer unit. If the number of characters to be printed in any line is less than the number of characters assigned to the first (leftmost) print head, only the print
5 wires in that print head are activated and turnaround may occur at any earlier point. If the number of characters to be printed exceeds those for the first print head but is less than or equal to a nominal line length, then all print heads may be activated on a selective basis and a nominal
10 line turnaround occurs. If the number of characters to be printed extends beyond the nominal line length for all print heads, then the last (rightmost) print head prints its assigned characters plus all characters extending beyond the nominal line length, and turnaround will occur later than
15 nominal turnaround. The printer unit includes turnaround input means, margin means, and turnaround control means, all cooperating to accomplish these objectives. The printer subsystem incorporates microprocessors for communications and control functions and storage facilities. The storage
20 facilities, besides storing significant control and data information, also are provided with tables which represent the various print head configurations and which are accessed during printing operations to determine the optimum turnaround points that are available. In conjunction with the
25 printer unit, a print emitter is provided that is scanned during movement of the print heads. The print emitter has an additional track referred to as a turnaround track which is referenced upon completion of printing and which is utilized to insure a more accurate and effective turnaround operation.

30 Advantageous effects of the invention

The partial line turnaround device according to the invention is a solution to the complex problem of bi-directional printing with partial line turnaround (either right or left) utilizing multiple printing heads.

It provides greater throughput and further an accommodate different character densities more efficiently.

It requires only a single emitter to provide signals indication of the positional location of the printing heads and
5 for defining successive stopping and turnaround points in a line of printing during printing operations.

Description of one way of carrying out the invention by reference to the drawings

For a better understanding of the present invention, together with other and further advantages and features thereof,
10 reference is made to the description taken in connection with the accompanying drawings which illustrate one specific embodiment.

Brief description of the drawings

15 Fig. 1 is a simplified system diagram for the printer subsystem.

Fig. 2 illustrates the printer console and a number of printer components as well as forms feeding.

Fig. 3 is a frontal view of the printer unit in the printer
20 console of Fig. 2.

Fig. 4 illustrates an operator panel useful with the printer of Figs. 1 and 2.

Fig. 5 shows a mode switch for control of on-line, off-line conditions.

25 Fig. 6 shows a gate assembly with printed circuit cards.

Fig. 7 is a frontal view of the printer console of Fig. 2 with the cover open showing a print emitter.

Fig. 8 is an exploded view of various printer assemblies including the forms feed assembly, the print assembly and the ribbon drive assembly.

5 Fig. 9 is a cross-sectional view at the print line of the printer of Figs. 2, 3, and 8.

Fig. 10 is a right side elevation of various printer assemblies shown in Fig. 8.

Fig. 11 is a view of a ribbon shield having a print aperture positioned in a horizontal plane.

10 Fig. 12 is a cross-sectional view of the ribbon shield on the lines 12-12 in Fig. 11.

Fig. 13 is an overhead view of the printer slightly from the rear of the unit showing the forms feed open.

15 Fig. 14 illustrates a print wire block assembly and associated guide.

Figs. 15 and 16 illustrate front and rear faces of the guide shown in Fig. 14.

Figs. 17-19 illustrate an alternative mounting of print wire actuators with an angled face on the block assembly.

20 Figs. 20-22 illustrate mounting of print wire actuators with a flat face on the actuator block assembly.

Figs. 23-26 illustrate a print wire actuator, a plurality of which are mounted in the block assembly shown in Fig. 14.

25 Figs. 27 and 28 illustrate an alternative forms feed assembly for the printer unit.

Fig. 29 illustrates the arrangement of print wires in groups relative to a left margin in the printer unit.

Fig. 30 illustrates printing of characters at 10 characters per inch and 15 characters per inch.

- 5 Figs. 31 and 32 illustrate the print emitter and its operating scheme.

Figs. 33A and 33B, when arranged as shown in Fig. 34, show in greater detail the relationship of the print wires to character locations on the forms to be printed.

- 10 Fig. 35 is a generalized block diagram of the printer control unit shown in Fig. 1.

Figs. 36 and 37 further illustrate the arrangement of dots to form characters and the relationship of the print wires to the various character locations.

- 15 Figs. 38-40 illustrate various systems in which the printer subsystem may be connected.

Fig. 41 illustrates a stream of information between the host system and the printer subsystem.

- 20 Fig. 42 illustrates significance of bits in the frames during a receive mode when information is transferred from the controller to the printer subsystem.

Fig. 43 illustrates bit significance for the frames during a transmit mode when information is transferred from the printer subsystem to the controller.

- 25 Fig. 44 illustrates the bit configurations for printer addressing.

Fig. 45 shows command and data arrangements in the information stream.

Fig. 46 is a chart illustrating a typical transfer of data to be printed.

- 5 Figs. 47A and 47B illustrate representative operational and formatting commands.

Figs. 48 and 49 illustrate frame layout for status reports during a Poll operation.

- 10 Fig. 50 is a block diagram of various circuit components used in the printer subsystem of Figs. 1 and 2.

- 15 Figs. 51A and 51B, when arranged as shown in Fig. 52, comprise a block diagram of the printer control unit including a Communications microprocessor (CMM) and a Control microprocessor (CTM) as well as a number of elements in the printer unit.

Fig. 53 illustrates a typical data transfer and printing operation in the printer subsystem.

- 20 Fig. 54 is a generalized flowchart of the operations performed by the Communications microprocessor (CMM) shown in Fig. 51A.

Fig. 55 is a generalized flowchart of the operations performed by the Control microprocessor (CTM) shown in Fig. 51B.

Figure 56 illustrates utilization of registers in the Control microprocessor.

- 25 Figs. 57-60 illustrate several actuator block configurations for 2, 4, 6, and 8 print heads.

Fig. 61 illustrates a print emitter for a printer having two print head groups while fig. 62 illustrates a print emitter for a printer unit having two print head groups.

5 Fig. 63 illustrates various conditions that may be encountered during partial line turnaround.

Fig. 64 illustrates various timing conditions when the printer is moving left from a turnaround emitter or is moving left from a right margin emitter area.

Fig. 65-68 illustrate flowcharts for Analysis routines.

10 Fig. 69 is a flowchart representing a right margin routine.

Figs. 70 and 71 are flowcharts representing head moving right in print area, printing complete (entered at real emitter:10 CPI character count even).

15 Fig. 72 further illustrates the relationship of print wires and print locations on a document during start-up of printing.

Description of Printer Subsystem and Printer Mechanisms

20 In order to best illustrate the utility of the present invention, it is described in conjunction with a high speed matrix printer, typically capable of printing in a high range of lines per minute on continuous forms. The particular printer subsystem described herein is associated with
25 a host system or processor, responds to command and data signals from the host to print on the forms and in turn provides status signals to the host during operations.

The printer itself is an output line printer designed to satisfy a variety of printing requirements in data processing,

data collection, data entry, and communications systems. It can be used as a system printer or a remote work station printer.

The following printer highlights are of interest:

- 5 Print density of 10 or 15 characters per inch (25,4= mm) selectable by the operator or by the using system program;
- 10 Condensed print mode, 15 characters per inch saves paper costs and makes report handling, mailing, reproduction, and storage easier;
- Line spacing of 6, or 8 lines per inch or any other line density selectable by the operator or by the using system program;
- 15 Incremental and reverse forms movement selectable by the using system program;
- Sixteen self-contained character sets selectable by the using system program with a base language selected by hardware jumpers.
- 20 Special graphics ability (special characters, graphs, plotting, etc.) selectable by the using system program;
- Matrix printing technology;
- Built-in diagnostics for problem determination by the operator;
- Microprocessor control unit;
- 25 Maximum print line width - 330,2 mm.

Maximum print positions for 10 characters per inch -
132;

Maximum print positions for 15 characters per inch -
198;

5 Adjustable forms width - 76,2 to 450 mm;

Maximum forms length - 76,2 to 317,5 mm;

Fig. 1 illustrates a representative system configuration including a host system 1 and the printer subsystem 2 which includes a printer control unit 3 and printer electronics 4.

10 Command and data signals are provided by the host system by way of interface 5, and command and control signals are provided from printer control unit 3 to the printer electronics 4 by way of bus 6. Status signals are supplied by printer control unit 3 to host system 1 by way of interface

15 5. Typically, the host system 1 generates information including commands and data and monitors status. Printer control unit 3 receives the commands and data, decodes the commands, checks for errors and generates status information, controls printing and spacing, and contains printer

20 diagnostics. Printer electronics 4 executes decoded control unit commands, monitors all printer operations, activates print wires, drives motors, senses printer emitters, and controls operator panel lights and switching circuitry. It controls the tractor/platen mechanism, the ribbon drive, the

25 print head (i.e., actuator group) carrier, the operator panel, and the printer sensors.

The elements of the system, such as the printer control unit and printer electronics, incorporate one or more microprocessors or microcomputers to analyze commands and data and

30 to control operations.

Figs. 2 and 3 illustrate various components of the printer

all of which are housed in the console 10. Various access panels or covers such as those designated 11, 12, and 13 are provided. Top cover 11 has a window 14 that enables an operator to observe forms movement during operation of the printer and when the cover is closed. Forms (documents) 15 are provided from a stack 16 and can be fed in one embodiment upwardly or downwardly as viewed in Figs. 2 and 3 by means of a forms feed assembly 20 which includes one or more sets of forms tractors such as the upper set comprising tractors 90 and 91. A forms guide 28 guides the forms after printing to a takeup stack, not shown but positioned below the printing mechanism and to the rear of the printer console. The printer incorporates a print assembly 30 that is positioned generally in a horizontal relationship with respect to forms 15 at a print station 32. Print assembly 30 is more clearly visible in other views. This is also true of the printer ribbon drive assembly 40 which is located in closer proximity to the front of the printer. Printer control unit 3 and its associated microprocessors are generally located behind the side cover 13.

As best seen in Fig. 3, a ribbon 41 is provided on one of the spools 42 or 43, which are disposable. Each box of ribbons would preferably contain a disposable ribbon shield 46 that fits between print assembly 30 and forms 15 to keep ribbon 41 in proper alignment and to minimize hold ink smudging on forms 15. Two motors shown more clearly in Fig. 8 drive ribbon 41 back and forth between spools 42 and 43. The printer control unit detects ribbon jams and end of ribbon (EOR) conditions. A ribbon jam turns on an error indicator and stops printing. An EOR condition reverses the ribbon drive direction.

The printer includes an operator panel 26 (shown in greater detail in Fig. 4) that consists of several operator control keys (pushbuttons 51-55 and 60), two indicator lights 56, 57, a power on/off switch 58, and an operator panel display 59. By using various combinations of the keys in conjunction

with the shift key 55 the operator can: start or stop printing and view the last line printed, set print density, position the forms up or down one page or one line at a time, move the forms incrementally up or down for fine
5 adjustment, and start or stop the diagnostic tests when selected by a mode switch, to be described.

The indicator lights on the operator panel display notify the operator that: the printer is ready to print data from the using system (indicator light 57), the printer requires
10 attention (indicator light 56), the current print density setting (panel display 59), errors, if any, have been detected, and the results of the diagnostic tests (panel display 59).

A 16-position mode switch 65 is located behind the front door 12 and is shown in greater detail in Fig. 5. The
15 on-line positions permits printing to be controlled by the using system. All other positions are off-line and do not allow printing to be initiated from the using system.

The first two switch positions are used by the operator to select these modes:

20 On-line. The normal operating position. With the switch in this position, the printer accepts commands from the using system. The operator panel display 59 indicates any detected error conditions.

25 Buffer Print. An additional on-line position which prints the EBCDIC values (hexadecimal codes) sent from the host and the associated character images. No control characters are interpreted. This feature allows the user to view the data stream sent to the printer.

30 Test. For off-line checkout and problem determination. In test mode, when Start key 53 is pressed, the Attention indicator 56 stays on and Ready indicator 57 is turned

on until the diagnostic tests that are stored in the printer control unit are finished or the Stop key is pressed. If an error is detected, the printer stops and displays an error code in the operator panel display 59.

The remaining thirteen (13) positions of the mode switch designated "2-9" and "A-E" are used by service personnel to select a variety of diagnostic tests to aid in off-line problem determination and confirmation of service requirements.

Fig. 6 illustrates a gate assembly 17 located behind side cover 13, Fig. 2, the gate assembly including modular printed circuit cards such as cards 8 that contain much of the circuit elements for printer control unit 3 and printer electronics 4, Fig. 1.

Fig. 7 is a frontal view of a print emitter assembly 70 that includes an emitter glass 71 and an optical sensor assembly 72. Glass 71 is vertically positioned with respect to sensor assembly 72 and is mechanically attached to print mechanism 30 so that as the print heads, print actuators, and print wires move back and forth left to right and conversely as viewed in Fig. 7, glass 71 also moves in the same manner with respect to sensor assembly 72 to indicate horizontal position of the print wires. Cabling 73 supplies signals to the print actuators which are described in detail below.

Overview of Printer Mechanisms

Figs. 8, 9 and 10, among others, show the detail of construction of the forms feed assembly 20, the print assembly 30, the ribbon drive assembly 40, and various associated emitters. A general overview of these assemblies is first presented.

As best seen in Figs. 8 and 10, forms feed assembly 20 has

end paltes (side castings) 21 and 22 which support the various forms feed mechanisms including a drive motor 23 to drive tractors 90-93, the motor having a forms feed emitter assembly 24. The forms feed assembly has a separate end of forms and jam detector emitter 25. Assembly 20 also includes a platen 29 located behind the forms and against which the print wires 33 are actuated during printing (See Fig. 9).

The print assembly 30 includes a base casting 75 supporting various mechanisms including print motor 76, shown in phantom in Fig. 8 in order that other elements may be seen more easily, and connected to drive a print head carrier 31 with actuator block assembly 77 in a reciprocal fashion horizontally to effect printing on an inserted form. The print assembly also drives the print emitter assembly 70 having emitter glass 71 and optical sensor assembly 72.

The ribbon drive assembly 40 includes a support casting 44, a cover 45, and drive motors 49 and 50.

Forms Feed Assembly

In order to load paper in the printer the forms feed assembly 20 pivots away from the base casting 75 at pivot points 80 and 81, the latter pivot point being best seen in Fig. 10, to allow access to thread the forms into position. Latches 83 and 84 are raised by the operator so that extremities 83a and 84a disengage eccentric pins 85 and 86 on the forms feed assembly. The forms feed tractor then pivots away from the operator as viewed in Figs. 3 and 8 and to the right as viewed in Fig. 10. This allows access to tractors 90-93 so that the operator may load paper. The forms feed assembly is then reclosed and relatched by latches 83 and 84 for normal machine operation. During the time that the forms feed assembly is pivoted back for service, a switch 94 prevents machine operation. This switch is actuated by a tang 95 on forms feed assembly 20 when it is closed.

Referring to Fig. 8, the forms feed assembly includes means for adjusting for forms thickness. As mentioned, the entire forms feed assembly pivots back from the rest of the printer about pivot points 80 and 81. In the closed position the forms feed assembly is in such a position that a spiral cam 96 engages a pin 97 on the main carrier shaft 98 of the print assembly 30 (see also Fig. 9). Adjustment of the spiral cam and knob assembly 96 is such that it rotates the main carrier shaft 98. Assembly 96 is retained in position by a spring loaded detent assembly. This has a spring loaded pin which engages notches in the knob so that it is held in the position set by the operator. Associated with shaft 98 are eccentrics such as portion 98a on the left end of shaft 99 with tenon 100 onto which latch 83 is mounted. Rotation of shaft 98 thus moves latches 83 and 84 which changes the distance between assemblies 20 and 30 and thus the distance between the ends of print wires 33 and platen 29. This adjustment enables the printer to accomodate forms of various thicknesses. The printer can handle forms from one part to six parts thickness.

The paper feeding is accomplished by the four sets of tractors 90-93 two above the print line and two below the print line. The individual tractors include drive chains to which pins are attached at the proper distance to engage the holes in the form. As an example, tractor 90 has drive chain 101 with pins 102. Chain 101 is driven by a sprocket 103 attached to a shaft 104 which also drives the sprocket and chains for tractor 91. Tractors 92 and 93 are driven from shaft 105. Because the tractors are above and below the print line, the printer is able to move the paper in either direction. The normal direction of forms drive is upwardly in Figs. 3 and 8. However, it is possible to move the paper downwardly, as well.

Rotation of shafts 104 and 105 and forms feeding is accomplished by appropriate drive of motor 23 in the proper direction which in turn drives pulleys 106 and 107 (to which

shafts 104 and 105 are connected) from motor pulley 108 by means of drive-timing belt 109. Cover 110 covers belt 109 and pulleys 106-108 during rotation. The forms feed emitter assembly 24 includes an emitter wheel 47 with marks to
5 indicate rotation and a light emitting diode assembly 48 that serve to indicate extent of rotation of motor 23 in either direction and as a consequence, the extent of movement of the forms as they are driven by motor 23.

The capability of the printer to feed paper in both directions offers some advantages. For example, in order to
10 improve print visibility at the time the Stop button is pushed by the operator, the paper may be moved up one or two inches above where it normally resides so that it can be easily read and can be easily adjusted for registration.
15 When the Start key is depressed, the paper is returned to its normal printing position back out of view of the operator. The printer may also be used in those applications where plotting is a requirement. In this case a plot may be generated by calculating one point at a time and moving the
20 paper up and down much like a plotter rather than calculating the entire curve and printing it out from top to bottom in a raster mode.

End of forms and jam detection is accomplished in this assembly by a sprocket 112 just above the lower left tractor. The teeth in this sprocket protrude through a slot
25 113a in the flip cover 113. This sprocket is not driven by any mechanism but simply is supported by a bearing. The sprocket engages the feed holes in the paper as it is pulled past by the tractor assemblies. On the other end of
30 the shaft 114 from the sprocket is a small optical emitter disc 115. The marks in this disc are sensed by an LED phototransistor assembly 116 and supplied to the electronics of the subsystem. The electronics verifies that marks have passed the phototransistor at some preselected frequency
35 when the paper is being fed. If the mark is not sensed

during that time, the machine is shut down as either the end of forms has occurred or a paper jam has occurred.

5 The castings 88 and 89 supporting the tractors 90-93 are adjustable left or right in a coarse adjustment in order to adjust for the paper size used in a particular application. After they are properly positioned they are locked in place on shaft 67 by locking screws such as locking screw 87.

10 All tractors are driven by the two shafts 104 and 105 from motor 23 as previously described. The motor adjusts in the side casting 21 in slots 120 in order to provide the correct tension for belt 109.

Besides the coarse adjustment, there is also a fine adjustment which is used to finally position in very small increments laterally the location of the printing on the forms. 15 This is done by a threaded knob 66 which engages shaft 67 to which both tractor castings clamp. This shaft floats between side castings 21 and 22 laterally. The threads in knob 15 engage threads on the right end of shaft 67. The knob is held in a solid position by a fork 68. Therefore 20 knob 66 stays stationary and the threads driving through the shaft force shaft 67 laterally left or right, depending upon the direction in which knob 66 is rotated. Shaft 67 is always biased in one direction to take out play by a spring 69 on the left end of shaft. As the paper leaves the top of 25 the tractors, it is guided up and toward the back of the machine and down by the wire guide 28.

In order to insure that the distance between the pins in the upper tractors is in correct relationship to the pins in the lower tractors an adjustment is performed. This adjustment 30 is made by inserting a gauge or piece of paper in the tractor assembly which locates the bottom pins in the correct relationship to the top pins. This is done by loosening a clamp 121 on the end of shaft 104. Once this position is

obtained, then clamp 121 is tightened and in effect phases the top set of tractors to the bottom set so that holes in the paper will engage both sets of tractors correctly.

Forms may be moved through the tractor forms feed mechanism manually by rotating knob 122. This knob simply engages the top drive shaft 104 of the upper tractor set and through the timing belt 109 provides rotational action to the lower tractor set, as well.

Print Assembly

10 In Fig. 8, a carrier 31 comprising actuator block 77 and support 78 accommodate all the print heads with their wire actuators 35 and print wires 33. Also, see Figs. 13 and 14-26. Actuator block 77 is designed to hold from two up to eight or nine print head groups of eight actuators each.

15 Thus, a printer with eight print head groups, as shown in Figs. 8 and 13, has sixty-four print wire actuators and sixty-four associated print wires. Only two actuators 35 are shown positioned in place in Fig. 8. The other sixty-two actuators would be located in apertures 133 only a few

20 of which are depicted. To insure long life of the print wires, lubricating assemblies 134 containing oil wicks are positioned in proximity to the print wires. The print wire actuators fire the wires to print dots to form characters. Carrier 31 is shuttled back and forth by a lead screw 36

25 driven by motor 76. Lead screw 36 drives the carrier back and forth through nuts which are attached to the carrier. When carrier 31 is located at the extreme left, as viewed in Figs. 3 and 8 (to the right as viewed in Fig. 13), this is called the "home position". When the carrier is moved to the

30 home position, a cam 37 attached to the carrier engages a pin 38, the pin being attached to the main carrier shaft 98. If the machine has not been printing for some period of time, in the neighborhood of a few seconds, the printer control unit signals the carrier to move all the way to

35 the left, in which case cam 37 engages pin 38 to rotate the main carrier shaft 98 approximately 15 degrees. On each end

of the shaft are the eccentrically located tenons, such as tenon 100, previously described. These tenons engage the latches 83 and 84 so that the distance between the print assembly and the forms feed assembly is controlled by the latches. As shaft 98 rotates, the eccentrics associated with latches 83 and 84 separate the forms feed assembly from the print assembly.

The purpose of motor 76, of course, is to move the carrier 31 back and forth in order to put the print actuators 35 and print wires 33 in the proper positions to print dots and form characters. Since the motion is back and forth, it requires a lot of energy to get the mass of carrier 31 and actuators 35 stopped and turned around at the end of each print line. A brushless DC motor is used. The commutation to the windings in the motor is done external to the motor through signals sent out of the motor via a Hall effect device emitter 39. In other words, the emitter 39 within the motor sends a signal out telling the printer control unit that it is now time to change from one motor winding to the next. Therefore, there are no rubbing parts or sliding parts within the motor, and switching is done externally via electronics based on the signals that the motor sends out from its emitter. The motor draws about 20 amperes during turnaround time and, because of the high current it draws and because of the torque constant required from the motor, it is built with rare earth magnets of Samarium cobalt which provide double the flux density of other types of magnets.

Samarium cobalt is not just used because of the higher flux density but also because its demagnetization occurrence is much higher and, therefore, more current can be sent through the motor without demagnetizing the internal magnets.

During printing, carrier 31 that holds the print actuators 35 goes at a velocity of approximately 63,5cm per second. The turnaround cycle at the end of the print line requires 28 milliseconds approximately, resulting in a Gravity or "G"

load in the neighborhood of 4 G's. The carrier, with all the actuators mounted, weighs about 3,85 Kg.

The current necessary to fire the print actuators is carried to the actuators via the cable assemblies 73, Figs. 7 and 13, one for each group of eight actuators. The cabling, such as cable 73a, Fig. 8, is set in the machine in a semi-circular loop so that as carrier 31 reciprocates it allows the cable to roll about a radius and therefore not put excessive stress on the cable wires. This loop in the cable is formed and held in shape by a steel backing strap 74. In this case there is one cable assembly for each group of eight actuators or a maximum of eight cable backing strap groups.

Ribbon Drive Assembly

The ribbon drive assembly 40 for the printer is shown in Fig. 8, but reference is also made to Figs. 3, 9, and 13. Spools 42 and 43 are shown with spool flanges but may be structured without spool flanges and contain the ribbon. The spools can be seen on either side of the machine near the front, Fig. 3. Gear flanges 118 and 119, Fig. 8, support ribbon spools 42 and 43, respectively. Drive for spool 43, as an example, is from motor 50, pinion gear 132 to a matching gear 119a formed on the underneath side of gear flange 119 then to spool 43. In one direction of feed, the ribbon path is from the left-hand spool 42 past posts 125 and 126, Figs. 3, 8 and 13, across the front of the ribbon drive assembly between the print heads 34 and forms 15, then past posts 127 and 128 back to the right-hand ribbon spool 43. A ribbon shield 46 to be described in conjunction with Figs. 11-13 is generally located between posts 126 and 127 and is mounted on the two attachment spring members 130 and 131.

Ribbon Shield

Fig. 11 illustrates ribbon shield 46 that is particularly

useful in the printer described herein. Fig. 12 is a cross-sectional view along the lines 12-12 in Fig. 11. Shield 46 has an elongated aperture 46a extending almost its entire length. The aperture enables the print wires 33 to press
5 against the ribbon in the printer through the shield in order to print on forms 15. Shield 46 has slits 46b and 46c at opposite extremities to permit easy mounting in the printer on spring members 130 and 131 of the ribbon drive assembly, Fig. 13.

10 Assembly View

Fig. 13 is an assembly view of the printer including forms feed assembly 20, printer assembly 30, and ribbon drive assembly 40. Ribbon drive assembly 40 includes the two ribbon spools 42 and 43 which alternatively serve as supply
15 and takeup spools. If spool 42 is serving as the supply spool, ribbon 41 will be supplied past posts 125 and 126, through the ribbon shield 46 past posts 127 and 128 and thence to the takeup spool 43. Shield 46, Figs. 11 and 13, and ribbon 41, Fig. 13, are illustrated slightly on the bias
20 relative to horizontal which is their more normal relationship in the printer. The ribbon drive assembly 40 is also positioned on a slight bias relative to horizontal to accommodate the bias of shield 46 and ribbon 41. In this condition aperture 46a assumes a horizontal relationship with
25 respect to the print wires 33 and forms 15.

Thus, in Fig. 13, the rightmost end of shield 46 is somewhat elevated in relation to the leftmost end in order that aperture 46a is maintained in a relatively horizontal position with respect to the print actuators in print mechanism
30 30. A few of the groups of print wires 33 are indicated at a breakaway section of shield 46. As previously noted, the print wires are reciprocated back and forth laterally in relation to a form, not shown in Fig. 13, in order to effect the printing of characters. The reciprocation is by means

of drive mechanisms activated from motor 76. The activating signals for the actuators in print mechanisms 21 are supplied through cabling indicated at 73.

Actuator Block, Guide, and Actuators

5 Enlarged views of the actuator block 77, guide 79, print wire actuators 35, lubricating assemblies 134, and various related mechanisms are shown in Figs. 14-23. Referring to Fig. 14, this better illustrates the arrangement of aper-
10 tures 133 in actuator block 77 which can accommodate eight print heads with eight print wire actuators. Apertures 133a are used to mount actuators 35 while apertures 133b allow passage of barrels 136 of actuators 35 through actuator
15 block 77 and guide 79 up to the print line. A typical lubricating assembly 134 comprises a cover 140, felt element 141, wick assembly 142, and housing 143 that contains lu-
bricating oil.

Fig. 15 illustrates a portion of face 79a of guide 79 while Fig. 16 illustrates a portion of face 79b of guide 79. Barrels 136 of actuators 35 pass through apertures 145 on
20 face 79a of guide 79 and are retained by bolts such as bolt 146 passing through apertures 147 from the opposite side of guide 79. Individual actuator barrels 136 and print wires 33 project through apertures 148, Figs. 13 and 16.

Figs. 17-22 illustrate several arrangements which permit
25 mounting of a greater multiplicity of actuators in a given amount of space through actuator block 77 and guide 79. Figs. 17-19 illustrate one possible mounting arrangement for the actuators while Figs. 20-22 illustrate the actual moun-
30 ting arrangement previously described in conjunction with Figs. 8, 13, and 14-16.

In Figs. 17-19 which represent an alternative mounting arrangement, print actuators 35a and print wires 35 for one

print head set of eight (1-8) are arranged on a straight slope 150. This slope, combined with actuator block 77a having a double angle configuration at 151, Fig. 18, results in a staggered print wire face-to-platen condition, Fig. 19.

5 This print wire face-to-platen distance, shown as 8X, is critical to both the stroke and flight time of the print wires.

The preferred arrangement, Figs. 20-22, has a number of attributes, including improved functioning, increased coil clearance, and ease of manufacture. In this method, print wires 35 arranged in a set 1-8 are mounted in two offset sloped subsets 152a and 152b forming a sloped serrated pattern. (See also Figs. 15 and 16.) Subset 151a includes print wires 1-4 of the set while subset 152b includes print

10 wires 5-8. This, combined with a straight surface 153 on actuator block 77 and angled actuators 35, Fig. 21, represent an in-line print wire face-to-platen condition as in Fig. 22. The print wire face-to-platen condition as in Fig. 22. The print wire face-to-platen distance, shown as X, is

15 at a minimum. This permits a higher printing rate and prevents wire breakage. The offset sloped print wire sets gives a greater clearance between wire positions which allows a larger actuator coil to be used.

20

Use of a straight surface 153 instead of the double angle 151 facilitates manufacturing of the actuator block and thereby reduces cost. However, brackets 155 are still cut at an angle such as shown in Fig. 24. The angular relationships of the print actuators 35a with respect to the platen faces in Fig. 18 and print actuators 35 with respect to the

25 platen face in Fig. 21 are somewhat larger than would be encountered in an actual implementation but they are shown this way to make the relationships easier to see. In contrast, an actual angular relationship might be smaller such as the

30 $4^{\circ} 30'$ angle front face 155a on bracket 155 of actuator 35 in Fig. 24.

35

Figs. 23-26 illustrate a preferred form of actuator 35. A print wire is provided having an armature which is retained in home position by a permanent magnet. When printing of a dot is required, an electromagnet is energized which over-comes the magnetic forces of the permanent magnet and propels the print wire toward the paper.

Fig. 23 illustrates one side elevation of the actuator, while Fig. 24 illustrates the opposite side elevation. The actuator comprises a number of elements arranged in a generally concentric manner on bracket 155. It is noted that Fig. 24 is somewhat enlarged relative to Fig. 23. Reference is also made to Figs. 25 and 26 for details of the individual components of the actuator. Also, it is noted that some slight structural differences appear between the actuator shown in Figs. 23-26 and those illustrated in Figs. 17-22, the actuators in Figs. 17-22 being more diagrammatically illustrated. The actuator includes a barrel 136 for supporting print wire 33 in proper relationship for printing when mounted in actuator block 77 and guide 79. Attached to the leftmost end of print wire 33 as viewed in Fig. 25 is an armature 156 which is arranged against a stop portion 156a of an adjustment screw 157 by forces exerted from a permanent magnet 158. A lock nut 159, Fig. 23, retains adjustment screw 157 in proper position. Thus, when not active, armature 156 and print wire 33 abut against stop 157a. When it is desired to actuate print wire 33, electromagnet 160 is rapidly impulsed from an external source by way of connectors 161. Energization of coil 160 overcomes the magnetic flux forces of permanent magnet 158 moving armature 156 and print wire 33 to the right as viewed in Fig. 25 thus causing the rightmost end of print wire 33 which is in proximity to the forms, to print a dot on the forms. A bobbin housing 162 is made of metallic substances to provide a shielding effect with respect to electromagnet 160. It is found that this has been beneficial when numerous print wire actuators are mounted in position on actuator block 77 and guide 79 since

it prevents stray impulses from reacting from one actuator to another nearby actuator. This has proven to be extremely advantageous when multiple print actuators are provided as in the present printer. A core element 163 provides a
5 forward stop location for armature 156 in readiness for restoration by permanent magnet 158 against stop 157a as soon as current is removed from coil 162.

Figure 26 is an end elevation of housing 162 along the lines 26-26 in Figure 25.

10 Alternative Forms Feed Assembly

Figs. 27 and 28 illustrate an alternative single direction forms feed assembly 170 which feeds forms only in the upward direction as viewed in these figures. In contrast with the forms feed assembly previously described in conjunction with
15 Fig. 8, this forms feed assembly has only a single upper set of tractors 171 and 172. A driving motor 173 provides driving force through gears 175 and 176 by way of timing belt 178. The various elements comprising the forms feed assembly are supported in a left end plate 180 and a right
20 end plate 181. Fig. 28 is a left end elevation of the forms feed assembly 170 illustrating the positional relationships of motor 173, timing belt 178 and other elements. A cover plate 182 covers timing belt 178 during operations. Driving of the pin feeds on the two tractors 171 and 172 is analogous
25 to the driving of the pin feeds for forms feed assembly 20 illustrated in Fig. 8 and previously described. In forms feed assembly 170, the tractor drive includes a drive shaft 183.

Lateral support for the forms feed assembly 170 is provided
30 by an upper support 185 and a lower support 186. The assembly also includes a platen member 29a. Other elements such as knobs 1 and 22a, 66a, and 96a are analogous to their counterpart elements 122, 66, and 96 shown in Fig. 3. The

zontal dot columns (1 and 9) are for spacing between characters. Any one wire can print a dot in four of the seven remaining horizontal dot positions (2 through 8). The printer can print 10 characters per inch or 15 characters per inch.

Most of the characters printed use the top seven wires in the group to print a character in a format (or matrix) that is seven dots high and seven dots wide. The eighth (bottom) wire is used for certain lower case characters, special characters, and underlining.

The number of print wire groups varies according to the printer model, and typically can be 2, 4, 6 or 8 groups. Printing speed increases with each additional wire group.

There are 16 character sets stored in the printer control unit. Any of these sets may be specified for use by the using system program.

Fig. 31 is a representation of the emitter glass 71 also shown in Figs. 7 and 8 and associated with the print mechanism 21. It has sections called "Ramp", "Home", and "Left Margin". These are coded sections, designated Track A, Track B, and Track C. Track B is sometimes referred to as the "Turnaround" track. "Home" is indicated by all three tracks being clear. "Ramp" is when Track A and Track C are clear, but Track B is opaque. "Left Margin" is when only Track C is clear, and Tracks A and B are opaque. Left Margin can be told from Right Margin because Track B is clear on Right Margin whereas Track B is opaque on Left Margin. For convenience, glass 71 is shown in a more normal representation with the left margin areas to the left and the right margin areas to the right. In actuality, the emitter glass 71 is physically located in the machine with the right-hand part in Fig. 31 toward the left and the left-hand part in Fig. 31 toward the right as viewed in

Figs. 7 and 8. This is due to the fact that the associated optical sensor 72 is physically located at the rightmost area of the strip when the print mechanism is in home position, and glass 71 actually is moved past the optical sensor assembly 72 from left to right as the print mechanism moves from left to right away from home position.

Fig. 32 illustrates the development of emitter pulses from the emitter strip 35 shown in Fig. 31, the signals being termed "real emitters" when actually sensed from Track A. "Option" emitters (sometimes referred to as "false" emitters) are developed electronically in the printer control unit. The use of emitter 70 in keeping track of printing location is described. The emitter tells the electronics when the wires are in a proper position to be fired to print the dots in correct locations. It essentially divides the print line into columnar segments, each one of which is available to the electronics to lay down a print dot. Track A, the basic track which controls the printing of dots has spacings of 0,56 mm. This corresponds to two print columns distance on the emitter in a normal print cycle and for ten characters per inch one option is inserted halfway in between.

Each emitter track actuates one pair of light emitting diode-photo transistor (LED-PTX) sensors within sensor assembly 72. Track A provides print initiation pulses, Track B provides turnaround information, and Track C indicates if the print heads are in either left or right margin.

If the line to be printed is shorter than the maximum print line length, typically 330,2 mm, then a signal for turnaround (reversal of print motor 76 direction) is given as soon as the last character has been printed. The motor now decelerates until it comes to a stop, and then immediately accelerates in the reverse direction until nominal speed is reached.

To keep track of the print head position, the number of emitters of Track A are counted. The A sensor keeps increasing the count regardless of whether the print assembly moves to the right or left. In order to indicate the true position of the print assembly, provision is made electro-
5 nically to convert this count so that the count increases when the print assembly moves in one direction and the count decreases when moving in the opposite direction.

In order to accomplish this, Track B has been added. It is
10 assumed that the print assembly is moving to the right. After the last character has been printed and the signal for turnaround has been given, the print assembly will continue to move to the right and the count will increase. However, as soon as the next transition has been reached on Track B,
15 the count is frozen. The print head now comes to a stop and reverses. When it again passes the transition where the count was frozen, the emitter counts will now be subtracted and a true position indication is maintained by the counter for Track A.

20 The length of the Track B segments are chosen to be longer than the distance it takes the print head to come to a stop. The higher the print head speed and the longer the turnaround time, the longer must be the Track B segments. Thus, if the line is shorter than 132 characters at ten characters
25 per inch, the carrier need not travel all the way to the right end of the print line. It may turn around soon after the printing is completed.

Figs. 33A and 33B, when arranged as shown in Fig. 34, comprise a diagram showing the physical relationship of the
30 print heads when in the home position relative to character locations on a form to be printed. In addition, the emitter relationships are shown.

In Fig. 33A, print head 1, comprising eight print wires, is

normally to the left of the nominal left margin when in home position. Print head 2 lies to the right of the left margin when the print assembly is in home position and the other print heads up to eight, as an example, are physically located at successively further positions to the right in relation to the form. The print wires are arranged in a sloped serrated pattern and are displaced two character positions apart horizontally, as shown in Fig. 37, and one dot location apart vertically. In order to print the character "H" as shown in inset 195, it is necessary that all of the print wires in print head 1 sweep past the "H" character location to effect printing of the individual dots. As each wire passes by and reaches the appropriate position for printing of its assigned dot locations in a vertical direction, it is fired. Thus, formation of characters takes place in a flowing or undulating fashion insofar as the printing of the dots is concerned. That is, an entire vertical column of dots as in the left-hand portion of the character "H" is not formed all at once but is formed in succession as the eight wires in print head 1 sweep past that column. This is true of the printing of all other character columns, as well. As a result of this, each print head is required to pass at least far enough so that all of the wires in that print head will be able to print both the first vertical column of dots in the first character required as well as the last column of dots in the last character to be printed in the group of character locations assigned to that print head.

Accordingly, print head 1, during printing movement of carrier 31, prints all of the characters that normally would appear underneath print head 2 when the print heads are in their home position. The printing of dots associated with print head 2 takes place under the home position for print head 3 and so on.

Inset 196 illustrates the relationship of real and optional

emitters, sometimes referred to as "false" emitters, for both ten characters per inch and fifteen characters per inch. During the printing of characters at ten characters per inch, real emitters are found as indicated. These are physical real emitters derived from the emitter glass 71 as the print assembly sweeps from left to right or right to left during printing. The same real emitters are used for printing at fifteen characters per inch. However, when printing is at ten characters per inch, one additional (optional) emitter is necessary between each successive pair of real emitters to form the individual characters while, if characters are printed at fifteen characters per inch, two additional (optional) emitters are required between each successive pair of real emitters to handle the printing of dots for those characters.

Inset 197, Fig. 33A, illustrates the character locations associated with the rightmost print wire of print head 2 and the leftmost print wire of print head 3. Print heads 4-7 are not shown since the relations essentially repeat those shown with respect to print heads 1-3. The rightmost wires of print head 8 are shown in Inset 198, Fig. 33B. In addition, Inset 199 shows that for ten characters per inch, 132 characters can be accommodated in a full print line while for fifteen characters per inch, 198 characters are accommodated.

Fig. 35 is a highly diagrammatic block diagram of the general relationship of various system and control unit components including the two microprocessors 200 and 210 (also designated MPA and MPB), the Head Image Generator 220 and the random access memory 217 and indicates how the information is transferred that is generated by the Head Image Generator to print dots on the paper by actuation of the actuators.

Microprocessor 200 handles communications; microprocessor 210

handles the control of the subsystems. Microprocessor 200 sets up in memory 217 the count and the text buffer that is to be printed at a selected addressable location. The information is then passed over to microprocessor 210 or the
5 buffer that is to be used. The count is passed to the Head Image Generator 220 and also the address in memory 217 which is the text buffer to be printed. Head Image Generator (HIG) 220, knowing the buffer to be printed, accesses memory 217 and defines the dots for the characters to be printed at
10 each of the successive columns assigned to each print head as print carrier 31 moves during printing. HIG passes the data to the Control microprocessor 210 giving it all the dots to be printed at that particular time. This is represented in Fig. 37 which includes a portion of head 1 and all
15 of head 2. Fig. 37 illustrates printing at ten characters per inch. A string of "H's" is assumed to require printing. The darkened dots of the "H's" represent the wires above them that will actually print that dot. For example, in print head 1, wire 4 prints the fourth dot down in the first
20 column of the leftmost "H". This is the second slice of firing for that particular character with another three wire fires being required for wire 4 to complete the horizontal bar portion of the "H". The other seven wires in print head 1 fire at appropriate times to complete their assigned
25 horizontal rows in that character. At head 2, wire 1 is over an "H"; there is no wire over the next "H"; and wire 5 is over the third "H". If printing was at fifteen characters per inch, there would be no wires over two characters between wires 1 and 5 of head 2, rather than just one character
30 as illustrated.

The wire layout of "1 5 2 6 3 7 4 8" in Fig. 37 relates to the layout in Fig. 36 where it is shown how an "H" is laid out in relation to the actual wire slices.

Printer Attachment

35 The printer subsystems may be connected by an interface

cable to a controlling device (controller). The printer can be connected to the controlling device itself, or to another printer (or work station unit) with additional cabling.

Controlling Device

- 5 The controlling device to which the printer subsystem is attached may be a host computer system, Fig. 38, or a controller at a remote work station, Fig. 39. In either case, all information transfers (exchanges) between the controlling device and the printer control unit are started
10 from the controlling device by a command. Information transfers ordinarily are not initiated by the printer.

In some applications, the printer subsystem may be directly connected to a host computer system, as in Fig. 38. In such applications, all commands (operational and formatting) are
15 supplied by the computer, along with the data to be printed. Responses from the printer are sent directly to the computer from the printer control unit.

In other applications, Fig. 39, the printer subsystem may be connected to a work station controller, which in turn is
20 remotely connected to a host computer system by a communications network - such as Systems Network Architecture/Synchronous Data Link Control (SNA/SDLC). In such applications, information (data) to be printed and printer formatting commands are transferred from the computer system to the
25 work station controller. The work station controller then generates the operational commands and transfers all this information to the printer. Responses from the printer are sent to the work station controller then to the computer system by the communications network.

30 Cable Through Connector

The Cable Through Connector feature, Fig. 40, connects multiple printers or other work station units on the same

interface cable line to the system or controller.

Units with this feature have address-setting switches and an additional cable connector. The customer assigns a unique address to each unit on the cable connector line and sets
5 the address switches at installation time. The feature is not needed on the last unit on the line. The number of units that can be connected to the same line depends on the capability of the controlling device.

10 With this feature, the maximum cable length restriction is from the controlling device to the last unit on the line.

Audible Alarm

The optional alarm produces a tone that alerts the operator to conditions that require operator attention.

Interface Cable

15 The interface cable may be either coaxial or twinaxial. Representative maximum cable lengths from the controller to the last device on the interface are:

Coaxial cable	-	610 m
Twinaxial cable	-	1525 m

20 The type of cable selected depends on the requirements of the controlling device to which the printer subsystem is attached.

Information Transfer

Data Stream

25 All information transferred between the controlling device and the printer subsystem is in the form of a serial "stream" of information bits, Figs. 41. Contained in this stream are:

Bit synchronization patterns
Frame synchronization patterns
Data frames

5 The bit and frame synchronization (sync) patterns establish timing control between the controlling device and the printer. The data frame is the unit of information used to transfer all commands, data to be printed, and status information.

10 The data stream can flow in either direction on the interface cable - but only in one direction at a time (half-duplex). The controlling device always initiates the data stream flow for either direction. Only one device on the interface can be communicating with the controlling device at a time.

15 The data stream flows on the interface for each transfer of single or multiple frames of information. The cable carries no signal between information transfers.

20 In a typical information transfer from controller to printer, the information stream may be a mixture of operational commands, formatting commands, and data to be printed. Blocks of up to 256 frames may be included in the information stream for a given transfer.

25 The information stream for any information transfer always begins with the bit-sync and frame-sync patterns, and ends with an end-of-message code in the last frame of the sequence. The end-of-message code causes turnaround on the cable, allowing status information to be transferred in the opposite direction on the cable on the next sequence.

Information Frame

30 The basic unit of information transfer is a 16-bit information frame. The information frame is used for transferring

all commands, data, and status information between the controlling device and the printer. A Receive mode from controller to printer is illustrated in Fig. 42 and a Transmit mode from printer to controller is illustrated in Fig. 43.

The 16 bits of the information frame are assigned the following significance: Bits 0 through 2, the fill bits, always 000, are for timing control. Bit 3, the parity bit, is set to maintain an even bit count (even parity) in each frame.

Bits 4, 5, and 6 are the address bits for selecting a specific printer (or other work station unit) attached to the interface. Up to seven units can be addressed by combinations of these bits (000 through 110 are valid addresses). A bit combination of 111 indicates an end-of-message and causes line turnaround.

Bits 7 through 14 are for commands, data or status information. Bit 15, always on, is a synchronization bit.

Printer Addressing

Printer addresses are coded in bits 4, 5, and 6 of the information frame, Fig. 44. The address for a single printer on the interface cable is 000. With the Cable Connector feature, addresses can range from 000 through 110. Addresses of printers attached with the Cable Connector feature are set with switches by the customer. A bit combination of 111 is used as an end-of-message indicator in the last frame of a transfer sequence and, therefore, cannot be used as a valid address.

The first frame following any signal turnaround on the cable is a command frame containing a valid printer address (000 through 110) for selecting a specific printer on the interface cable. Each successive frame following a command frame

is then checked for the end-of-message code (111).

All response frames from the printer to the controlling device, except the end-of-message frame, contain the address of the selected printer.

5 Printer Responses

All information transfers between the controlling device and the printer are initiated from the controlling device by command frames. The printer, however, does transfer information to the controller on request. These transfers are
10 called printer "responses".

In general, printer response frames are requested by the controller to determine the readiness (or "status") of a printer for accepting data from the controller. A variety of printer operational and error conditions are reported to
15 the controller by means of printer response frames. These conditions are described in detail in the section below entitled "Status and error Information".

Printer Control Unit

The printer control unit 3 (See Figs. 1 and 35, as examples)
20 connects the printer to the interface cable from the controlling device, controls the flow of information to and from the controlling device and controls all internal printer functions.

When data is received for printing, the printer control unit
25 formats the data into print lines, using formatting commands (control codes) embedded in the data stream. Two print-line format buffers are used so one line can be printed while the next line is being formatted. This comprises a "lookahead" function which allows bidirectional printing for maximum
30 throughput.

Information Codes

5 All 256 8-bit codes of the Extended Binary Coded Decimal Interchange Code (EBCDIC) are recognized by the printer control unit. In a data stream hexadecimal codes of 00 through 3F represent formatting commands, 40 through FE represent data (FF is always a blank character.)

All of these codes may be used to represent characters.

Operational Commands

10 Operational commands, listed in Table I below, determine the printer function to be performed, such as Write Data, Read Status, etc. (also, see Figs. 45 and 47A). Fig. 47A illustrates a representative operational command: "Poll." Some operational commands require an additional command or data frame. In these cases, the next frame transmitted must
15 contain that command or data frame. Operational commands are embedded in the data stream wherever required for proper control of the printer.

Operational Command Sequence

20 The diagram in Fig. 46 illustrates a representative sequence of events between a controlling unit and the printer subsystem to effect printing of data.

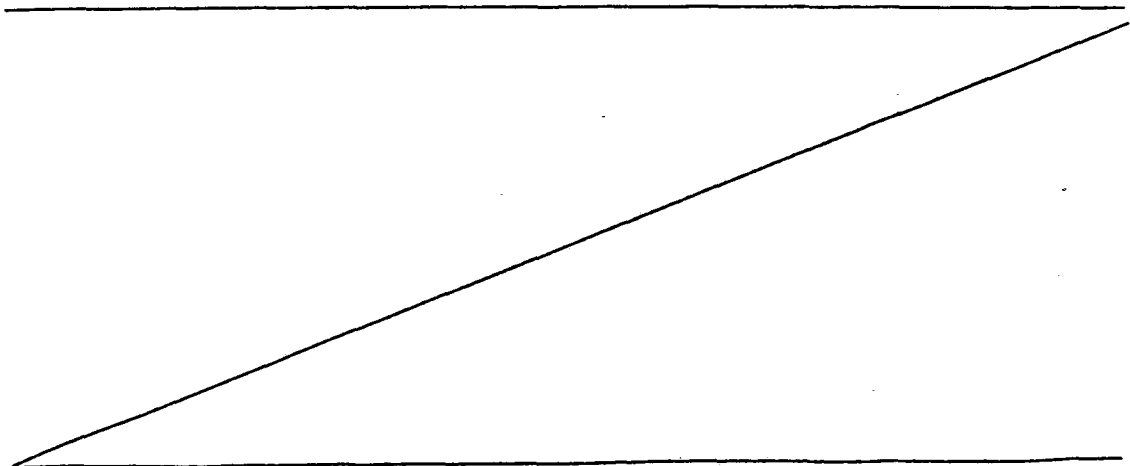


TABLE I

OPERATIONAL COMMAND SUMMARY

	<u>Command Name</u>	Hex <u>Code*</u>	<u>Function</u>
5	Poll	X0	Poll causes a one-frame status response from the printer until a Set Mode command is issued; thereafter, Poll initiates a two-frame status response. Bit
10			8 set to 1 resets line parity error indication. Bit 9 notifies the printer to send current status frames.
15	Read Device ID	0C	Initiates the transfer of the ID (Identifier) frame from the printer to the controlling device. Must be followed by an Activate Read command.
20	Read Status	88	Initiates the transfer of one frame of outstanding status from the printer. Must be followed by an Activate Read Command.
25	Activate Read	00	Required to complete Read Device ID or Read Status operations. This command signals the hardware that data is to start a transfer and is not placed in the command queue.
30	Write Data	1E	Causes the printer to store all data frames after the Activate Write.

TABLE I -continued-

5	Activate Write	01	Causes printing of data frames that follow this command. This command signals the hardware that data is to start a transfer. This is not placed in the command queue.
	Write Control Data	05	Resets exception or outstanding status.
10	Set Mode	13	Must be issued before the printer accepts any other command except Poll and Reset. Followed by a data frame that defines the interval between frames.
15	Reset	02	Resets printer to a power-on reset condition.
	Clear	12	Clears all print data buffers.
	End-of-Queue (EOQ)	62	Marks end of command queue loading.

* Bits 7 through 14 of a data frame

20 Formatting Commands Formatting Command Function

Formatting commands, shown in Table II below, control forms movement and line length. They are embedded in the information stream that follows the Write Data command, Fig. 45.

25 Also, See Fig. 47B which illustrates a representative

formatting command: "New Line."

Some formatting commands require more than one frame. A code in the first frame identifies multiple frame commands. In some cases the code in the second or third frame further defines the total number of frames to be used. The formatting command codes are also referred to as "standard character string" (SCS) codes. SCS is an SNA control-character subset.

TABLE II

10 FORMATTING COMMAND SUMMARY

	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		1	2	3	4	5	6	
15	Null (NUL)	00						No Operation performed.
20	Carriage Return	0D						Moves the print position to the first position of the current line.
	New Line	15						Moves the print position to the first position of the next line.
25	Interchange Record Separator (IRS)	1E						Same as New Line.

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		1	2	3	4	5	6	
10	Line Feed (LF)	25						Moves the print position to the same horizontal position of the next line.
	Form Feed (FF)	0C						Moves the print position to the first position of the next page.
15	Bell (BEL)	2F						Turns off Ready, turns on Attention and the audible alarm, and stops printing.
20	Absolute Horizontal Position (AH)	34	CO	NN				Moves the print position to the horizontal position specified in the parameter frame. The parameter frame NN immediately follows the AH command.
25								

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
	Absolute Vertical Position (AV)	34	C4	NN				Moves the print position specified in the parameter frame. The para- meter frame NN immediately fol- lows the AV command.
10								
	Relative Horizontal Print Position (RH)	34	C8	NN				Moves the print position hori- zontally towards the end of the line from the current print position the num- ber of columns specified in the parameter frame. The parameter frame NN immedi- ately follows the RH command frame.
15								
20								
	Relative Vertical Print Position (RV)	34	4C	NN				Moves the print position verti- cally towards the bottom of the page from the cur- rent print posi- tion the number
25								

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
10	Set Graphic Error Action (SGEA)	2B	C8	NN	GG	UU		Sets the unprint- able character option and de- fines the default graphic that is specified in the parameter frames. The parameter frames NN, GG, and UU immediate- ly follow the C8 command frame.
15								
20	Transparent (TRN)	35	NN					Permits the codes normally used as control charac- ters to be used as printable characters. The parameter frame NN specifies the number of frames that follows the 35 command frame.
25								
30	Subscript (SBS) <i>Not available for single direction paper feed;</i>	38						Line feeds 1,41 mm to print subscript characters.

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
10	Superscript (SBS) <i>Not available for single direction paper feed.</i>	09						Reverse line feeds down 1,41 mm to print superscript characters.
15	Set Character Distance (SCD)	2B	D2	04	29	P1	P2	Sets the charac- acter density to 10 or 15 characters per inch as specified in the P1 and P2 para- meter frames.
20	Set Baseline Increment (SBI) <i>Not available for single direction paper feed;</i>	2B	D2	04	15	P1	P2	Sets the depth of one line of print to 0,176 mm
25								
30	Set CGCS through Local ID (SCL) CGCS - Coded Graphic Character Set	2B	D1	03	81	P1		Loads 1 of 16 graphic charac- acter sets speci- fied in the P1 parameter frame.

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		1	2	3	4	5	6	
10	Absolute Move Base- line (AMB) <i>Not available for single direction paper feed</i>	2B	D3	04	D2	P1	P2	Moves the print position forward in the vertical direction from the current print position to the new print position speci- fied in the P1 and P2 parameter frames.
20	Relative Move Baseline (RMB) <i>Not available for single direction paper feed.</i>	2B	D3	04	D4	P1	P2	Moves the print position forward or backward in the vertical direction from the current print position to the new print posi- tion specified in the P1 and P2 parameter frames.
30	Load Alternate Characters (LAC)	2B	FE	NN	MM			Data allows cus- tomer designed fonts or charac- ters to be loaded for printing.

TABLE II - continued -

FORMATTING COMMAND SUMMARY

5	Command Name and Abbreviation	Frame Sequence (Hex Code/Parameter)						Description
		1	2	3	4	5	6	
	Set Line Density (SLD)	2B	C6	NN	P1			Selects vertical line density of 6 or 8 lines per inch or any distance in multiples of 25,4mm/72 or 0,35 mm up to 255.
10								
	<u>Status and Error Information</u>							
15	<u>Poll Response Frames</u>							
	Following a power-on reset (POR), the printer subsystem responds to controller polling with a single status frame, Fig. 48. The printer continues to respond to controller polling with a single status frame until the printer receives a Set Mode command.							
20								
	After receiving a Set Mode command, the printer responds to polling with two status frames, the second of which is shown in Fig. 49.							
25	Status information described in frame 1, Fig. 48, is the same in either case.							
	<u>Bits 0, 1, 2 Fill .</u>							

These bits are always set to 000 and are used for
timing control.

Bit 3 -Parity.

This bit is used to maintain an even bit count (even parity).

Bits 4, 5, 6 - Printer address.

- 5 These bits are used for selecting a specific printer attached to the interface. Up to seven printers can be addressed by the combinations (000 through 110). A bit combination of 111 indicates an end-of-message and causes line turnaround.

10 Bit 7 - Busy.

0 = Not busy when operational command queue is empty.
1 = Busy when operational command queue is not empty or an activate command is received.

Bit 8 - Line parity.

- 15 0 = No line parity error is detected in a received frame.
 1 = Line parity error is detected in a received frame.

Bit 9 - Unit not available.

- 0 = Unit available (the Ready light is on).
20 1 = Unit not available.

Bit 10 - Outstanding status.

0 = No outstanding status.
1 = Outstanding status (available by using the Read status command).

- 25 Bits 11, 12, and 13 indicate a variety of exception status conditions. Until the exception status is reset, only Poll,

Set Mode, and Reset commands are processed. The Write Control Data Command (if the exception status is not power-on transition) is also processed. The power-on transition exception status is reset by the Set Mode command. The
 5 exception status conditions are reset by the Write Control command (see "Write Control Data").

	<u>Bit 11</u>	<u>Bit 12</u>	<u>Bit 13</u>	<u>Meaning</u>
	0	0	0	No exception status exists.
10	0	0	0	Activate lost - caused by a line parity error following a Write Data, Read Status, or Read Device ID.
	0	1	0	Invalid activate command - caused when a Write Activate follows a Read Status or Read Device ID or, a Read Activate following a Write Data.
15				
	0	1	1	Reserved.
	1	0	0	Invalid command - caused when a command is outside the operational command set or more than 240 micro-second interframe interval has been specified.
20				
	1	0	1	Input queue or input buffer overrun - caused when more than 16 commands and associated data frames or more than 256 data frames have been sent.
25				
	1	1	1	Power-on transition-causes only status frame 1 to be sent in response to a Poll command.

Bit 14 - Current/Previous response level.

5 When bit 14 goes from 0 to 1 or 1 to 0, the using system determines that the response frame is current status. When bit 14 is unchanged from the previous response, the using system determines that the response frame is previous status. Any change in the response frame changes bit 14 from its previous state. Bit 14 is set to 0 after power-on.

Bit 15 - Sync.

10 A synchronization bit that is always set to Frame 2 contains information shown in Fig. 49.

Bit 0 through 6 - Same as Poll status frame 1.Bit 7 - Invalid SCS (Standard Character String) control

15 0 = No Invalid SCS Control Code is detected.
 1 = Invalid SCS Control Code is detected.
 Reset by a Reset or Clear command.

Bit 8 - Invalid SCS (standard character string) parameter

20 0 = No Invalid SCS parameter is detected. 1 = Invalid SCS parameter is detected.
 Reset by a Reset or Clear command.

Bit 9 - Receive buffers full.

Used by the using system to determine when data can be sent to the printer.

25 0 = Receive buffers are not full.
 1 = Receive buffers are full.

Bit 10 - Print complete.

5 The print complete bit is set to 0 when the printer detects an Active Write command. The print complete bit is set to 1 by Power-on reset, a Clear command, a Reset command, or when all input data is printed.

0 = Printing is in progress.

1 = Printing is completed.

Bit 11 - Cancel Request.

10 The Cancel request bit is set to 1 when the operator presses the Cancel key on the Operator Panel. This bit is reset by the next Poll command (with Acknowledge bit set to 1), a Reset or Power-On reset.

0 = No cancel request.

1 = Cancel request.

15 Bit 12 - Not used.

Bit 13 - Not used.

Bit 14 - Graphic check.

20 This bit is set to 1 indicates that an undefined character has been detected in the data stream. This bit is reset by the next Poll command (with Acknowledge bit set to 1), a Reset or Power-On reset.

0 = No graphic error is detected.

1 = Graphic error is detected.

Bit 15 - Same as Poll status frame 1.

25 Read Status Response Frame

One response frame is sent for every Read Status command.

The response frame, sent only after the Activate Read command is received, contains a hex code that defines the status condition within the printer.

5 The hex code corresponds to the last two digits of the error code that may be available as a system error message (depending on the using system). The first digits of these hex codes are also automatically displayed on the printer operator panel 26 when the error occurs.

The defined conditions are:

10	<u>Hex</u> <u>Code</u>	<u>Error Condition</u>
	11	Printer controller error
	12	Cable adapter error
	31	Head drive problem
15	32	Margin emitter not detected
	34	Turnaround emitter not detected
	35	Print emitter not detected
	36	Head busy (cannot be reset)
	37	Printer control unit
20	38	Overcurrent
	41	Forms drive problem (undetermined area)
	42	Forms busy (cannot be reset)
	43	Forms emitter B not detected
	44	Forms emitter A not detected
25	45	Run latch failure (printer control unit)
	46	Printer control unit
	47	Overcurrent
	48	Emitter sequence wrong
	80	Ribbon jam
30	81	Ribbon jam (diagnostic mode)
	82	Ribbon problem
	83	Head Image Generator error

Printer General Block Diagram

Fig. 50 illustrates various printer blocks of interest. A power supply 245 supplies the unit with all the power to drive and to control. The on/off switch 240 controls power supply 245 being on and off. From the power supply the cover interlock switch 242 enables and disables the 48-volt drive which controls much of the printer logic 243. Logic 243, once enabled, looks at operator panel 26 for information as to the operations to be performed. Mode switch 65 tells the logic which type of operation in testing procedures should be run. Print assembly 30 is controlled by the printer logic along with the forms assembly 20. Emitter devices 24 and 70 supply positional information to the printer logic. The printer logic also controls and talks with the interface panel 247 and passes information on the other parts of the printer. The ribbon motors 49 and 50 are controlled in an on/off fashion by printer logic 243 which accepts inputs from the ribbon assembly to determine when the end of ribbon has occurred. Head servo 252 is a control block that insures that the print head is in the proper position at the proper time for the actuators to fire. Forms servo 253 is a control block that moves the forms to desired locations. Fans 254-258 are used to control temperature within the machine. As indicated in connection with Fig. 35, printer logic 243 includes two microprocessor adapter blocks 200 and 210. The first one included is the Communications adapter CMA which accepts input and passes it to the second one which is the Control adapter CTA that actually controls the printer. These will be discussed in connection with Figs. 51A and 51B.

Microprocessor Control - Printer Subsystem

Two microprocessors are provided for the printer subsystem, each having its assigned functions and both can operate concurrently to accomplish the required functions. Figs. 51A and 51B join together as shown in Fig. 52 to illustrate the details of the Printer Control Unit 3 and Electronics 4,

Fig. 1. Various abbreviations used herein are listed in Table III below:

TABLE III

	ABO	-	Address Bus Out
5	CMA	-	Communications Adapter Card
	CTA	-	Control Adapter Card
	CTL	-	Control
	D	-	Data
	DI	-	Data In
10	DBI	-	Data Bus In
	DBO	-	Data Bus Out
	HIG	-	Head Image Generator
	MODE/OP	-	Mode/Operation
	ROS	-	Read Only Storage
15	SAR	-	Storage Address Register
	STG	-	Storage Bus In

There are actually seven main blocks comprising the Printer Control Unit representing seven printed circuit cards. The first block is the Communications Interface 201 between the host system and digital printer electronics. That interface communicates with the Communications Adapter (CMA) 202 which is a microprocessor card that takes the host information and compiles it into a form that can be used by the rest of the printer. The CMA includes Communications microprocessor CMM 200. From there, the information is passed on to the Head Image Generator 220 card for building images for the printer. There is another microprocessor card that is the Control Adapter Card (CTA) 211. The CTA includes Control microprocessor CTM 210. The Control Adapter handles the processed information from the Communications Adapter, controls all the mechanical elements of the printer, such as the motors, and receives emitter signals indicating positions of the mechanical elements. This Adapter handles communication with the actual hardware through the Control and Sense card 212 and the Head Latch card 213 that stores the data to be

200. The random access memory storage 217 has 3K bytes for the Head Image Generator and is where the Communications microprocessor stores character images to be printed. The character images in this storage are used by the Head Image
5 Generator to generate actual images for the slanted heads. Also, in the block of Random Access Memory are two text buffers and some scratch pad storage.

Because of the staggered slant geometry of the print head assembly and the multiple head configuration, a fairly
10 complex Head Image Generator 220 (HIG) is required to convert conventional character dot format to a slanted format. HIG processes the character images as they would normally appear in a "straightup" format, but slants them for the Head Latch block 213 to supply to the print wire
15 actuators. This is done through hardware routines that are performed in the Head Image Generator 220. There are basically two blocks in the Head Image Generator, one block being the Control block 221 that actually performs the hardware routines to take the unslanted image and slant it.
20 There is also a Data block 222 that is a small storage unit in which the Head Image Generator stores the slanted information currently being worked on. The Control Adapter 211 can then read this storage and output to the wire actuators through Head Latch 213. This is the slanted data.
25

The Control Adapter (CTA) 211 has six blocks within it. The Control microprocessor (CTM) 210 receives inputs from various sensors, e.g., ribbon reverse/jam, forms jam, head position, linear encoder, forms position encoder, as well as print commands and data from CMM 200 and HIG 220 and generates
30 print wire firing signals and various control signals to control the ribbon drive, print head drive, print wire actuators, and forms drive. The Control microprocessor (CTM) 210 has a ROS storage 232 that is 12K bytes of FSU ROS to contain its programs or routines. Certain communication
35 registers including Status register 225 and Command register 226 allow the Communications Adapter 202 and the Control

Adapter 211 to communicate with one another. Through these registers go commands such as Print commands, Forms commands, Carriage Returns, and the actual decoded messages that the host has sent over. An Input/Output stack 227 is used as a
5 local storage, that is, it is a small random access memory for the Control Adapter to store intermediate data and there is some associated decoding. The Decode block 228 handles the timing relationships for the Communications Adapter and Control Adapter to be able to talk to one another asynchro-
10 nously.

The Control and Sense card 212 handles the information from the Control Adapter card 211 and interfaces with the actual printer electronics to control by way of Decode block 233 and Printer Control block 234 the head motor, the forms
15 motor, and the ribbon motors represented by block 235. Through blocks 236 and 237 it senses the positional state of printer electronics and mechanics such as the print emitters, forms emitters, etc. The Head Latch card 213 is another
20 interface card from the Control Adapter that latches up the wire image data, the slanted data that is received from the Head Image Generator 220, and outputs it at the correct time to the print wire actuators so that the dots get printed in the correct place on the form.

A typical print operation is now described. It is assumed
25 that a single print line is provided by the host with a Forms Feed and Carriage Return at the end which is a typical situation. This information comes over in a serial stream from the host as analog signals into the Communications Interface 201 which digitizes the analog signal and stores
30 it in its Interface Storage 204 in the form of characters to be printed. A command informs the Communications Adapter 202 that this is a line to be printed and that it has Line Feed and Carriage Return commands. The Communications Adapter 202 seeing this information appear, will take the
35 characters to be printed out of the Interface Storage 204 and put them into a selected text buffer in CMA Storage "B"

on Communications Storage card 215. It then tells the Control Adapter 211 that it has information in a text buffer to be printed.

5 The Control Adapter, after receiving the information initially tells the Head Image Generator 220 (HIG) that there is data in the selected text buffer that needs to be slanted. Head Image Generator 220 then slants this information, while the Control Adapter card 211 starts the printer in motion; that is, it starts moving the print head carrier 31.

10 It moves the carrier through commands given to the Control and Sense card 212, and it looks for print emitters, or emitters which tell the Control Adapter when to fire wires; it checks for these signals coming from the Control and Sense card. When these signals appear, the CTM retrieves

15 the slanted wire information from the HIG and passes it to the Head Latch card 213 and fires the wires to print dots. The Control Adapter 211 for each print emitter that it sees, asks the Head Image Generator for a new set of slanted data. This is outputted to the Head Latch card 213 and is repeated

20 until the entire text buffer has been printed, that is, all the information that the host sent over. Once the Communications Adapter 202 has seen that this has taken place, that is, the printing has been done, it passes the Forms command to the Control Adapter 211. Control Adapter 211 decodes

25 this command and gives a command to the Control and Sense card 212 to move forms a certain number of forms emitters. It senses these forms emitters through the Control and Sense card again.

This is further illustrated in Fig. 53. A typical operation

30 is assumed to come from the host to the printer controller unit. [Steps (paths) are illustrated by numbers in squares]. Path 1 represents receipt of the data and commands by interface 201. By path 2, the interface prepares it and passes it on to the CMA 202. CMA 202, essentially in two

35 operations, strips off printable characters and by the path labeled 3A transfers the characters to the text buffers in

CMA Storage 216. Initially, font information is stored in
HIG Storage 217. At the same time essentially by path 3B,
the CMA 202 supplies print commands to the CTA 211 to start
the operation. Next are two operations 4A and 4B. CTA 211
5 initiates operation 4A to HIG 220 which simply says there is
data in the text buffer at a certain address, begin HIG
operations. At the same time, the path 4B is effective to
tell the Control and Sense card 212 to start any of a
number of possible operations of the printer, such as: to
10 move the heads off the ramp, move the forms as necessary, do
not move the forms, move the head to a certain absolute
position or relative position, etc. Path 5 is a path from
HIG 220, a flow from the HIG to the storage blocks 216 and
217 which essentially fetches the data and the font infor-
15 mation, that is the hexadecimal representation of the data
that it is supposed to operate on to start its wire image
generation. Path 6A represents verification by CTA 211 of
electromechanical printer operations. This involves checking
out the emitters, for example, timing out on the print
20 emitters, etc. to determine that the printer is prepared to
print and ready to fire reported back by path 6B.

Paths, 7A and 7B represent fetching of data from the HIG 220
which is the head latch image that is transferred to the
head latch card 213 and some checking is done on it at that
25 point by the CTM.

Path 8 represents CTA 211 signalling the head latch block
213 to fire. This is a pedestal signal to fire the wires.
Prior to that point, CTA 211 has to have received a print
emitter at step 6B in order to issue the pedestal firing
30 signal.

Path 9 represents a feedback signal from the Control and
Sense Card 212 and from the head latch card back to CTA 211.
CTA 211 will recheck the Control and Sense Card 212 verifying
that the operation was performed that was expected to be
performed.

Path 10 is a communication path from the CTA 211 to the CMA 202 indicating that the operation that the CMA initiated was accomplished without errors. If there were errors, CMA will be so advised. CMA 202 then compiles status or error information and presents it at Step 11 to the Interface 201 as a poll response to the host.

Communications Microprocessor (CMM) Operations

The Communications Microprocessor 200 (CMM) Flowchart, Fig. 54, represents its general operation and starts with the Power On Diagnostics being run. At the conclusion of Power On Diagnostics, the selected language is loaded into the font Memory for processing and printing. A decision is now made as to whether the Mode Switch is in the off-line or on-line position. If it is in the on-line position, then the interface data is processed, or information coming from the host or going to the host, is processed and prepared. If it is in the off-line position, then this process is skipped. Communication with the Control microprocessor 210 (CTM) allows the CMM to receive any errors or information that needs to be passed to the host and it allows the CMM to pass data and commands such as data to be printed, forms, spacing, etc. on to the CTM. Next, the Operator Panel is accessed to determine whether the Start button, Stop button, or other buttons have been depressed for entry information from the Operator Panel. Next, the Process forms or Control data block is checked to determine the movement of forms resulting from commands sent to the CTM. Next is to Process the text buffers which includes SNA commands or the off-line routines. The CMM places them in the proper text buffer to be printed by the CTM and directs the CTM to pick this information up and place it on the paper as dots. Then the CMM checks for online or off-line status and continues the process again.

Control Microprocessor (CTM) Operations

Fig. 55 is an overall block diagram of the operations of the Control microprocessor 210 (CTM). The CTM goes through Power On Diagnostics upon Power Up and then upon successful completion of that proceeds to Program Controls. The function of this is to look for and analyze commands from the Communications microprocessor (CMM) and start or continue forms operation. When a command is determined, if it is a Print Command, CTM starts the print head motor and looks for the first print emitter. Upon finding the first print emitter, CTM goes into the Print block and stays in that area printing the line of data until it reaches Print Complete representing complete printing of the line. Then CTM goes into the margin routines to find the margins or a turnaround emitter. Once the margins or the turnaround emitter are determined, CTM stops the print head, starts the forms and returns to Program Control to look for and analyze further commands. If CTM receives additional commands from the CMM, upon completion of the forms operation, it starts the next print operation. Out of any of these blocks, if an error is detected, CTM exits and goes into an error routine to determine what and where the error is. It notifies the CMM of the error. The CMM, based on the type of error, will either retry the command or stop the operation of the printer and notify the host.

Control Microprocessor Registers

The register layout for the Control Microprocessor 210 is shown in Fig. 56. As a convenience, the register assignments are listed below:

30	I00	EQU	R0	Input/Output Register
	I01	EQU	R1	Input/Output Register
			R2	Work Register
			R3	Work Register
			R4	Work Register

	PEMT	EQU	R5	Indicates Previous Emitters
	PHF	EQU	R6	Print Head Flags
	FRMST	EQU	X'1'	Forms Start Flag
	DNSCH	EQU	X'2'	Density Change Flag
5	PARK	EQU	X'4'	Ramp Command Flag
	PRCMP	EQU	X'8'	Printing Is Complete
	FLG1	EQU	R7	Indicator Flags
	CD15	EQU	X'1'	Character Density Equals 15 CPI
10	RV	EQU	X'2'	Printhead Is Going Left (Reverse)
	TXBUF	EQU	X'4'	Head Image Generator Is To Use Text Buf 2
	HIGST	EQU	X'8'	Head Image Generator Is To Start Print Lines
15	FLG2	EQU	R8	Ribbon Flags
	FBFLG	EQU	X'1'	Wire Feedback Flag
	RBMON	EQU	X'2'	Ribbon Motor Is On
	FMSTM	EQU	X'4'	Forms Time Flag
20	TOK	EQU	X'8'	Turn Around Is OK
	WIPOS	EQU	R9	Wire Position Counter
	FECT	EQU	R10	False Emitter Counter
	DIAGF	EQU	X'1'	Diagnostic Flag
	FDRCT	EQU	X'2'	Direction Of Forms Movement
25	FE2	EQU	X'4'	False Emitter 2
	FE1	EQU	X'8'	False Emitter 1
	PRERR	EQU	R11	Printer Error Flags
		EQU	X'8'	Not Used
	HHOME	EQU	X'4'	Head Home Flag
30	TEDGE	EQU	X'2'	Turnaround Edge Flag
	HATNA	EQU	X'1'	Head Stopped At Turn- around Flag
	CMDFL	EQU	R12	Command Flags
	PRCMD	EQU	X'1'	Print Command Flag

	PRPND	EQU	X'2'	Print Command Is Pending
	FMCMD	EQU	X'4'	Forms Command Flag
	TSCMD	EQU	X'8'	Test Command Flag
	EMCT1	EQU	R13	Emitter Counters - (Used
5				To Determine
	EMCT2	EQU	R14	Head Position By The
				Number Of
	EMCT3	EQU	R15	Emitters From Left Margin
	MAIN/AUX	EQU	D0, D0 Aux	Address Registers
10	MAIN/AUX	EQU	D1, D1 Aux	Address Registers
	MAIN/AUX	EQU	D2, D2 Aux	Address Registers
	RM1	EQU	D3	Indicates Right Margin
				When The
	RM2	EQU	D4	Emitter Counter Attains
15	RM3	EQU	D5	This Value

End Of Forms Indicators

	EOFI	EQU	D6	End Of Forms Indicators
	LASTD	EQU	X'8'	Last Forms Direction,
				1 = FWD, 0 = REV
20	LBUSY	EQU	X'4'	Busy History Indicator
	FBSEQ	EQU	X'2'	Busy Sequence Flag
	EOFER	EQU	X'1'	End Of Forms Detected
				Indicator
25	FMCT1	EQU	D7	16 Bit Forms AB Emitter
				Counter
	FMCT2	EQU	D8	
	FMCT3	EQU	D9	
	FMCT4	EQU	D10	
	SIGN	EQU	X'8'	Counter Sign Bit

30 Emitter Status Register

ESTAT	EQU	D11
-------	-----	-----

	LASTE	EQU	X'4'	Last End-Of-Forms Emitter Value
	LASTA	EQU	X'2'	Last Forms A Emitter Value
	LASTB	EQU	X'1'	Last Forms B Emitter Value
5		EQU	D12	
	FLECT	EQU	D13	Forms Lost Emitter Counter
	FMECT	EQU	D14	Forms Missing Emitter Counter
	PT1	EQU	D15	Program Timer 1 / Forms Command Count
10	FLAST	EQU	X'8'	8 Or More Forms Commands Flag

Description of Printer Block Assemblies and
Emitter Relationships

- 15 Figs. 57-60 represent print wire actuator block assemblies that accommodate 2, 4, 6 and 8 print heads, respectively. Each of these figures has a three numbered designation which supplies significant information. As an example, the designation in Fig. 57 which is for a printer unit having two
- 20 print heads is "2-8-4.4". These numbers mean that the printer unit has two print heads each having eight print wires and that the first print wire in one of the print heads is 4,4 inches (11,18cm) away from the first print wire in the second print head. Taking the designation in Fig. 60
- 25 as another example, this is "8-8-1.8"; this means that this particular printer unit has eight print heads, each having eight print wires and that the first print wire in one of the print heads is located 1,8 inches (4,57cm) away from the first print wire in the next succeeding print head.
- 30 Fig. 61 illustrates a print emitter that is useful with a printer unit having two print heads such as that illustrated in Fig. 57.

Fig. 62 illustrates a print emitter that is useful in a

printer unit having eight print heads such as that shown in Fig. 60. Various dimensions and physical relationships of the emitter areas are shown in Figs. 61 and 62. Since the print heads in a two-head unit are 11,18cm inches apart, a longer emitter is required to provide positional information as the print heads move along the print line. Since the two print heads are mounted securely in a fixed relationship, Fig. 57, only one emitter is necessary to provide positional information.

Referring to Fig. 60, the print heads are located much more closely together and thus the shorter emitter shown in Fig. 62 will suffice. It is noted that only the print heads at each extremity of the actuator block in Fig. 60 are illustrated but there are actually six additional intervening print heads between the two print heads shown. This also applies to the illustration in Fig. 58 since there are two intervening print heads between those shown at the extremities. In Fig. 59 there are four intervening print heads not shown, between the two print heads shown at the extremities.

In Figs. 61 and 62, the dimensions are given in millimeters. Thus, the overall extent of print emitters in the upper track which corresponds to Track A in Fig. 31 is 259,64 millimeters. As one example, the overall length of the print emitter pulses corresponding to those shown in Track A in Fig. 31 is 51,364 millimeters. The same principle applies to the other dimensions shown. It will be recalled that the print emitter 71 in Fig. 31 is illustrated in a more conventional sense with the left margin area to the left and the right margin area to the right. However, as was pointed out earlier, the emitter registration glass is physically located in just the opposite manner in the printer unit as viewed from the front of the unit and with this in mind, the emitter registration glass shown in Fig. 61, as well as that shown in Fig. 62, have the ramp, home and left margin areas at the rightmost extremity.

Partial Line Turnaround

Fig. 63 is a greatly simplified version of the relationships of the nominal right margin, the commands and various conditions that may be encountered during printing operations relative to the determination of a partial line turnaround. The first wire location is shown after which the forms and print command occurrences are indicated.

The nominal right margin is the minimum distance the print head must move to print from one to "n" characters. The term "n" characters equals the nominal line length for a given head configuration. The nominal right margin is shown on line 1 with a turnaround indicated at line 2 if printing at least moves to the nominal right margin.. If printing terminates sooner than the nominal right margin then turnaround may occur as indicated in lines 3 and 4.

Fig. 64 illustrates various timing conditions when the printer is moving left from a turnaround emitter or is moving left from a right margin emitter area. The chart provides information for printing both at 10 characters per inch and 15 characters per inch. Relationships are set up in the Control microprocessor storage and provide an indication as to when the first print emitter to be printed on may be encountered at the two printing densities. A point of interest is that the speed of the print motor is varied depending upon the print density. That is, the print motor moves more rapidly at 10 characters per inch since there are fewer dots to be printed and moves more slowly at 15 characters per inch since there are more dots to be printed. As a consequence of this, the emitters will occur more frequently during a 10 character per inch print operation than they will during a 15 character per inch operation. Actually the distance traveled is identical, assuming that the same amount of information needs to be printed but it takes about one-third longer to get from one emitter to the next emitter

location during the 15 character per inch printing operation than it does during the 10 character per inch operation. A number of figures in microseconds is provided to indicate the earliest and latest times for receipt of the first emitter pulse that can be used for printing operations after a turnaround or after having encountered the right margin area. This can be used by the Control microprocessor based on the first detected real emitter to adjust the relationship between the false emitters and the real emitters which should always be 450 microseconds.

Layout of Emitters

Reference is again made to the description concerning Fig. 32 and its relevance to the emitter glass 71 shown in Fig. 31 for a discussion of the turnaround areas that are provided on the emitters. These turnaround areas are pictured in track B of the two emitters illustrated in Figs. 61 and 62 as well. In connection with Fig. 32, the length of the segments in track B are chosen to be longer than the distance that it ordinarily takes the print head to stop. Thus, it is preferred that after it encounters the turnaround emitter edge, that the print head will be able to stop before encountering the opposite emitter edge for the same turnaround emitter area. The higher the print head speed and the longer the turnaround time, the longer are the track B segments.

The length of the track B segments may be reduced and print throughput correspondingly increased if an additional speed signal is introduced. The directional signal may be developed directly from an analog tachometer which provides a positive voltage when the motor rotates in one direction, and a negative voltage when it rotates in the opposite direction.

By adding the directional tachotemeter signal to the track B output, a distinction can be made between the printhead

continuing in the original direction when entering a new track B segment, and the print head returning to the just passed segment.

5 The major advantage of the emitter turnaround arrangement is the elimination of unwanted emitters. When the carrier and with it the sensor comes to rest at an emitter transition, Track A, then the slightest jitter of the carrier assembly may cause these unwanted emitters. These emitters are not registered with the scheme described since the emitter count
10 will be frozen at the Track B emitter turnaround transition.

Summary of Principles Used for Determination of
Partial Line Turnaround

The following summarizes the principles used in the determination of partial line turnaround.

- 15 When less than a full line of print is required, the print heads can stop and turn around before they reach the end of the maximum line length. The following principles will work for any number of wire matrix heads (#HD), head spacing (HDSP) and characters per inch (CPI).
- 20 Each head is assigned the option of printing a given number of characters during a single carrier movement. If the number of characters to be printed exceeds the maximum number of print positions for one head, then it becomes necessary to print a nominal line. A nominal line is defi-
25 ned as the number of print positions a head can print times the number of heads. This length is less than the maximum line length and the additional positions beyond a nominal line are defined as extended line printing (ELP). The additional positions will be printed with the rightmost print
30 head, which may or may not be the maximum line length.

For each head configuration, a table is used that identifies

the starting print position of the rightmost head (RMH) and the distance between the leftmost wire of each head (HDSP), see Table A.

TABLE A

5		<u>#HD</u>	<u>RMH</u>	<u>HDSP</u>
		2	59	11,18 cm
		3	87	9,14 -
		4	99	7,11 -
		5	103	5,59 -
10		6	125	5,59 -
		7	123	4,57 -
		8	141	4,57 -
		9	143	4,06 -

All additional numbers can be obtained from these two values. ELP is defined as RMH plus (HDSP) (CPI). K is a constant for each head and is defined as the distance from the leftmost wire to the rightmost wire. In the case of all wires being in a vertical plane, K would be 0. If the wires are sloped, as in the printer unit herein (See Figs. 33A and 33B), K is 1,4 inches (3,56cm). That is, there are fourteen character spacings at 0,1 inch (2,54mm) per character. STOP is defined as the last print position the rightmost head must print or pass through to complete a given character count (CHCT).

All line lengths can be defined into three areas and the following formulas are used in this sequence.

1. Definition of less than nominal line and its STOP formula.

$$\text{CHCT} < (\text{HDSP}) (\text{CPI})$$

$$\text{STOP} = (\text{CHCT}) + (\text{HDSP}) (\text{CPI}) (\# \text{HD1}) + (\text{K}) (\text{CPI})$$

2. Definition of nominal line length and its STOP formula.

$$\begin{aligned} \text{CHCT} &= (\#HD) (HDSP) (CPI) (K) (CPI) \\ \text{STOP} &= (K) (CPI) + (HDSP) (CPI) (\#HD) \end{aligned}$$

5 3. Extended line printing is anything not covered by 1 or 2 but does have its own STOP formula.

$$\text{STOP} = (\text{CHCT}) + (K) (CPI) (2)$$

The above description is for right partial line turnaround and left partial line turnaround would use the same type of calculations. There are two conditions that left partial could be considered:

- (1) is to start a nominal line at the point the last line ended or some point that would allow all of the line to be printed or,
- 15 (2) start to the left with ELP if ELP had been used and then finish with nominal printing. Less than nominal line length would be possible in all cases.

Advantages to be gained by use of partial line turnaround can be realized by inspection of the following table. This table uses the maximum line length printing time for each head configuration as a 100% and then shows the percentage increase when using partial line turnaround.

TABLE B

25	<u>Number of Print Heads</u>	<u>10 CPI Partial Line Turnaround</u>	<u>15 CPI Partial Line Turnaround</u>
	2	113%	118%
	4	97%	102%
	6	48%	52%
	8	9%	9%

30 The printing throughput is dependent upon the length of

print lines, spacing, and skipping and does not vary with the character set used by the printer. Printing throughput is for both maximum forms width and partial line turnaround formatted width. Throughput for typical documents would typically fall between the partial line turnaround and maximum values shown in the chart.

Actual Examples

Reference is made to Fig. 72 which illustrates the relationships of the print wires and printing or character locations on the document for printer units having two print heads in one case and eight print heads in another case. The principles of determining whether less than nominal line length, nominal line length, or extended printing is required is generally the same regardless of the number of print heads involved, the head spacing, or the number of characters to be printed. The following discussion is predicated on a maximum print line length of 132 character locations and involves printer units with both two print heads and eight print heads with the spacing shown in Fig. 72. Character location numbers are not directly allotted to print position numbers.

The following examples will illustrate conditions encountered during actual print operations involving printer units having two print heads and eight print heads, respectively.

A test is first made by the routines in the Control microprocessor to check whether or not the number of characters is less than a nominal line length. The following information pertains to printer units with both two heads and eight heads.

Situation No. 1: The leftmost print head will print the characters when they total less than the nominal line length and are all located in its assigned area.

2 Print Heads8 Print Heads

	CHCT < (HDSP) (CPI)	CHCT < (HDSP) (CPI)
	CHCT < (4,4) (10)	CHCT < (1,8) (10)
	CHCT < 44 (IF NOT, TEST	CHCT < 18 (IF NOT, TEST
5	FOR NOMINAL)	FOR NOMINAL)
	STOP = CHCT + [(HDSP)	STOP = CHCT + [(HDSP)
	(CPI) (#HD-1)] + (K) (CPI)	(CPI) (#HD-1)] + (K) (CPI)
	STOP = CHCT + [(4,4) (10) (1)]	STOP = CHCT + [(1,8) (10) (7)]
	+ [(1,4) (10)]	+ [(1,4) (10)]
10	STOP = CHCT + 44 + 14	STOP = CHCT + 126 + 14

The last print buffer position covered by the rightmost wire in the rightmost print head will be as follows:

	Rightmost wire, print	Rightmost wire, print
	head 2 will traverse	head 8 will traverse
15	print positions 59-101	print positions 141-157
	so that characters 1-43	so that characters 1-17
	will be printed in	will be printed in
	their entirety.	their entirety.

Referring to the information for the printer unit with two heads, as an example, if the character count is less than fortyfour, then all printing can be handled by Head No. 1. That is, Head No. 1 can print up to and including forty-four characters.

For a printer unit with eight heads, a test is made to see whether the character count exceeds eighteen characters.

If, in the case of the printer unit with two print heads, the number of characters in any selected line to be printed exceeds forty-four in number, then the routine proceeds to the next test which is to determine whether or not a nominal line length exists. The following information is pertinent for printer units with two heads and eight heads.

Situation 2: Print Head 1 plus other print heads are utilized in their assigned areas to print characters when they number less than or are equal to the nominal line length for the leftmost print head.

5	<u>2 Print Heads</u>	<u>8 Print Heads</u>
	$CHCT \leq (\#HD)(HDSP)(CPI) - (K)(CPI)$	$CHCT \leq (\#HD)(HDSP)(CPI) - (K)(CPI)$
	$CHCT \leq (2)(4,4)(10) - (1,4)(10)$	$CHCT \leq (8)(1,8)(10) - (1A)(10)$
10	$CHCT \leq 88 - 14$	$CHCT \leq 144 - 14$
	$CHCT \leq 74$ (If not, then use extended)	$CHCT \leq 130$ (If not, then use extended)
	$STOP = (K)(CPI) + (HDSP)(CPI)(HHD)$	$STOP = (K)(CPI) + (HDSP)(CPI)(HHD)$
15	$STOP = (1,4)(10) + (4,4)(10)(2)$	$STOP = (1,4)(10) + (1,8)(10)(8)$
	$STOP = 14 + 88 = 102$	$STOP = 14 + 144 = 158$

The last print buffer position covered by the rightmost wire in the rightmost print head will be as follows:

20	Rightmost wire, print head 2 will traverse to print position 102 in order that characters 44-74 will be printed in their entirety.	Rightmost wire, print head 8 will traverse to print position 158 so that print heads 2-8 can print characters 18-130, in their entirety and as may be assigned to their respective printing areas.
25		

From the tabulation, it can be seen that any line of printing that has less than or equal to seventy-four characters maximum can be printed by utilizing both of the print heads in a printer unit having two print heads. In the case of a

printer unit with eight heads, the significant character count is 130.

5 If the number of characters in a line to be printed exceeds 74 in the case of two heads, or 130 in the case of eight heads, then the routine proceeds to determine whether extended line printing is necessary and the following information is pertinent for this determination.

10 Situation 3: When the number of characters in a line extends beyond the nominal line length for all print heads, the rightmost print head prints all characters located beyond the nominal line length up to the maximum line length. (Example: 132 characters maximum for 10 characters per inch).

2 Heads

8 Heads

15	STOP = CHCT + (K) (CPI) (2)	STOP = CHCT + (K) (CPI) (2)
	STOP = CHCT + (1,4) (10) (2)	STOP = CHCT + (1,4) (10) (2)
	STOP = CHCT + 28	STOP = CHCT + 28

The last print buffer position covered by the rightmost wire in the rightmost head will be as follows:

20	Rightmost wire, print head 2 will traverse print positions 103-160 so that characters 75-132 will be printed in their entirety in extended line mode.	Rightmost wire, print head 8 will traverse print positions 159-160 so that characters 131-132 will be printed in their entirety in extended line mode.
25		

30 Considering the printer unit with two print heads, if 132 characters need to be printed in a given line, that is the maximum number of characters that can be accommodated at 10 characters per inch, the blank areas in the left and right

margin portions of the print line also need to be taken into account. These areas comprise 14 character locations each for a total of 28 character locations. When this is added to the 132 character maximum for 10 characters per inch, a total of 160 print positions is involved. So under these circumstances, and considering the printer unit with two print heads again, the two print heads will handle 74 characters of printing which is the nominal line length and Print Head No. 2 will continue past character position 74 for extended printing on up to the assumed maximum character count of 132.

When a printer unit has eight print heads, the extended printing in the line involves only a short distance for Print Head No. 8 in order to print character locations 131 and 132.

Analysis, Right Margin, and Print Line Determinations

Fig. 72 illustrates the relationship of print wires and print locations on a document during start-up of printing. Figs. 65-68 show the operations for analyzing commands. The control microprocessor reads the command register from the Communications microprocessor and tests if the parity bit is on. The parity bit being on dictates that the Communications microprocessor has had a parity check and has stopped. No further action would then be taken by the Control microprocessor. Next a check of a command validity bit is made which indicates that this command has been put in the register by the Communications microprocessor. If the validity bit is on, the command is moved to registers in the Control microprocessor and the microprocessor fetches the command data from the communications registers discussed in connection with the Control adapter 11, Fig. 51B. The command data and the communications data are Exclusive Ored together and outputted to the Communications adapter through communications registers, Figs. 51A and B. An echo bit is turned on at this time and an output made to the Status

register 225, Fig. 51B. The purpose of this is to route all command data from the Communications microprocessor through the Control microprocessor back to the Communications microprocessor in order to test the integrity of the communications path between the two microprocessors. If the data received back by the Communications microprocessor does not compare with the data that was sent, then an error is detected and the printer is stopped. Next a test is made to see if a Forms command has been received and if a Forms command is presently being performed. If a Forms command is not being performed then a check is made of the low order byte of the Forms Command and it is stored in an Input/Output register stack. A Forms command flag is turned on and a Forms Start flag is turned on. Also, the validity bit is reset to indicate to the Communications microprocessor that the command has been accepted. If a Forms command was not received (3B.Fig. 67), a test is made to see if it is a Print command that has been received. If not, the next check is to see if it is a Test command that has been received. If it is a Test command, the command data is stored in the Input/Output stack 227, Fig. 51B, in the test mode value, a Test command flag is turned on and the command validity is reset. If it was not a Test command, a test is made to see if a command is being performed and if any command is presently being performed, the command is not accepted at this time. If a command is not being performed, a Park flag is turned on and validity is reset.

If a Print command is assumed to have been received (1B. Fig. 65), a test is performed to see if a Print command flag is on. If this print command flag is on which means a print command is presently being performed, a Print Pending flag is turned on and a check is made to see if the head is moving left. If the head is not moving left, a check is made to see if print density is at 15 characters per inch. If the present density is not at 15 characters per inch, a check is made to see if the density was at 15 characters per

inch. If the result is Yes, a Density Change flag is turned on indicating that the next print line is at a different density than the present print line. After testing to see if the print density has been changed, if the acquired Print command is at 10 characters per inch, the character count is not even, it is adjusted to an even character count. The character count is not adjusted if it is an even number. The purpose of this is to keep the timing of the entry into the right margin routine identical for both 10 characters per inch and 15 characters per inch. The character count is then stored and the emitter count is calculated for this particular line of print.

If the Print command flag is not on (2A. Fig. 66), the print density at 15 characters per inch is checked. If a No results, then a check is made as to whether the density was previously 15 characters per inch. If the result is Yes, the motor controls are activated. A 15 character per inch speed flag is turned off and a 15 character per inch flag is also turned off. If the present density is 15 characters per inch and the density was not previously 15 characters per inch then the motor controls are fetched and the 15 character per inch flag and 15 character per inch speed control are turned on. In both cases directed the motor controls are activated.

After the change of density is processed, a check is made as to whether Text Buffer 2 is to be used and the flag for Text Buffer 2 is turned on or off as appropriate. An Head Image Generator Start flag is then turned on and the wire position counter incorporated in the head image generator, is initialized to a count of 9. The Print command flag is turned on, the print pending flag is turned off, the density change flag is turned off.

Print Density Analysis

For switching the printer back and forth between 10 characters

per inch and 15 characters per inch (Fig. 68), the nominal emitters for 10 characters per inch are read and saved in Nominal Emitter registers (4A. Fig. 68). The nominal character count for 10 characters per inch is inputted and
5 again saved in Nominal Character Count registers. A determination is then made if the print heads are moving left or right. If they are moving left, an adjustment of the nominal character position for the 10 characters per inch is made and it is saved in the Character Position registers.
10 Also the nominal character count is saved in the Character Position in Left Margin registers. If the print heads are not moving left but are moving to the right, an input is made of the maximum emitter count and it is saved in the emitter counter. The maximum character position count for
15 10 characters per inch is saved in the character position register. An input of the nominal character position for 10 characters per inch is made and it is saved in the Character Position in Left Margin registers. The operations remain the same is the nominal emitters for 15 characters per inch are
20 read (4B. Fig. 68). The new values are for 15 characters per inch and are substituted for the values for 10 characters per inch.

Right Margin

The nominal emitters and character counts necessary for the
25 partial line turnaround operation are determined (Fig. 69). That is, the emitter count at the right margin for the present line is calculated in terms of the number of emitters involved. The entry point is right margin. The first step is to input the nominal character count and move it into the work
30 registers for the Control microprocessor 210. An input of the nominal emitter count is made and this is saved in the work registers, as well. The commanded character count for this print line is inputted next and compared to see if the commanded character count is greater than the nominal character count. If the commanded character count is greater
35

than nominal, then the nominal character count is subtracted and the difference is multiplied by 9. That result is added to the nominal emitter count to determine the new right margin value. If the character count is less than or equal to the nominal character count, then the right margin value becomes the emitter count for the nominal character count. The result is moved to the right margin value registers if the result is greater than the present value in the right margin registers and then the routine returns.

10 Head Moving Right In Print Area and Completion
 of Printing

Fig. 70 and 71 illustrate the operations involved while printing is taking place and also at the completion of printing the determination of the term around point. It is assumed that the head is moving to the right in the print area and that printing has been completed. At 10 characters per inch, the character count is even which makes the timing the same for both 10 and 15 characters per inch. The print emitters are read and saved and a Turnaround Okay flag is turned off (30A. Fig. 70). This is a flag that indicates when the printer is able to stop the head and turn around going back in the opposite direction. The Wire Position counter is decremented and the Emitter counter incremented since the head is still assumed to be moving to the right. The character and emitter counts are maintained just as if printing were taking place even though there is no longer any firing of the print wires. A check is made to see if the Density Change flag is on which means that the print density has been changed from 10 characters per inch to 15 characters per inch or vice versa and, if so, the head is driven to the margin before attempting to change the print density. If the density is not changed, a timer is set for 625 microseconds and a check is made of the Forms Start flag. If it is on, that is, a 1, the Forms Start flag is reset. If the Forms Start flag is 0, a check is then made of the Turnaround Okay flag. If it is 0, the Print Pending

flag is checked. If the Print Pending flag is on, it indicates that a Print command for the following line of print has already been received. If it is not on, the Print command flag is checked which again indicates that a Print

5 command has been received but it has been received after the previous print was finished. In case both of these decision points are zero an attempt is made to acquire the next succeeding command from the Communications microprocessor. If the Print Pending flag is on, that is, is a 1, it indi-

10 cates that at this time the head is far enough right to begin printing the following cycle. Since during the previous print line cycle the next succeeding Print command is received, an adjustment can be made to the length of the current print line cycle to make sure it is always far

15 enough to the right to turn around and start the next line to the left. If Print command is on then, the microprocessor does not know yet if the head is far enough to the right. If the print head is far enough to the right it starts going back in the opposite direction, that is, to the

20 left to print the next succeeding print line. If Print Pending is on or if the head is far enough to the right then they both join to turn the Turnaround Okay flag on indicating that the head at this point is far enough to the right to turn around and go in the opposite direction a check is made

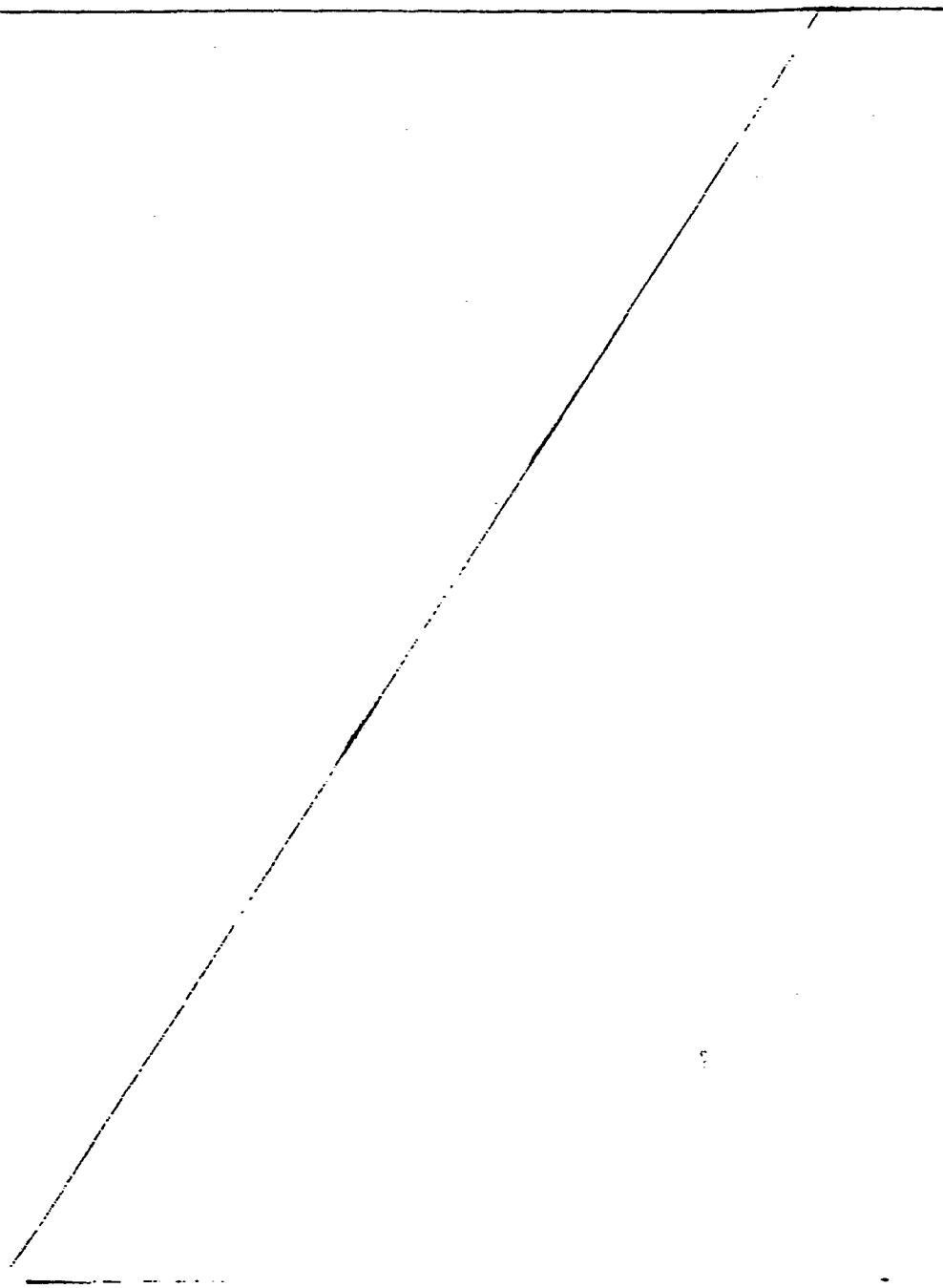
25 of the timer (B. Fig. 76). If the margin emitter is not on, a check is made to see if the timer has reached 0. If it has reached 0, an error has been detected. If it has not timed out yet a return is made to A back at the top of Fig. 71, operations continue until a print emitter or margin

30 emitter is detected. If the Turnaround Okay flag has been on, that is, a 1, a check is made to see if the turnaround emitter changed. If it was a 0 and became a 1 or was a 1 and became 0, this check will indicate that change. If the result is No, the print emitter is checked to see if it is

35 on just as though the Turnaround Okay flag had been off. If a change of the Turnaround emitter has occurred, a signal issued to stop the print motor, turn on the left motor control and a new right margin emitter count is calculated.

This right margin count is moved to the emitter counter and the operations come to an end (0.0A - Fig. 71).

5 While a preferred embodiment of the invention has been illustrated and described, it is to be understood that there is no intention to limit the invention to the precise constructions herein disclosed and the right is reserved to all changes and modifications coming within the scope of the invention as defined in the appended claims.



APPENDIX

Operation Codes

A number of operation codes are utilized by the microprocessors. These are listed below.

ALU OP CODES

5 -- MODE VALUE --
 REG TO REG 0 ____
 DAR TO DAR 1 ____
 REG TO DAR 2 ____
 DAR TO REG 3 ____
 10 MSK TO REG 4 ____
 MSK TO DAR 5 ____

Function OP Codes

	Add	A	0
	Add Carry	AC	1
15	Move	M	2
	Clear (0)	CLR	2
	Subtract/Borrow	SB	3
	Subtract	S	4
	Compare	C	5
20	Subtract Summary	SS	6
	Compare Summary	CS	7
	And	N	8
	Set Bit Off	SBF	8
	Test	T	9
25	And Summary	NS	A
	Test Summary	TS	B
	Or	O	C
	Set Bit On	SBN	C
	Shift Right	SR	D
30	Exclusive Or	X	E
	Shift Right Circular	SRC	F

Conditional Branches

	Branch Not Carry, Branch High	BNC,BH	C___ODD
	Branch Carry, Branch Less Than Or Equal	BC,BLE	D___EVEN
5	Branch Not Zero, Branch Not Equal, Branch True	BNZ,BNE,BT	E___ODD
	Branch Zero, Branch Equal, Branch False	BZ,BE,BF	F___EVEN

Unconditional Branches

10	Branch and Wait	BAW	C___EVEN
	Branch	B	D___ODD
	Branch and Link	BAL	E___EVEN
	Branch Via Link	RTN	F001
	Return and Link	RAL	F201
15	Branch Via DAR	BVD	F301

Select Data Address Registers (DAR's) and Storage (STG)

	Select Memory Data Low	SDL	FC01
	Select Memory Data High	SDH	FE01
	Select Memory Inst Low	SIL	F481
20	Select Memory Inst High	SIH	F489
	Select Data Bit X Off	SXF	F441
	Select Data Bit X On	SXN	F445
	Select Main DARS	SMD	F501
	Select Aux DARS	SAD	F701

Input/Output, Load/Store Ops

	Input From Device	IN	68__
	Sense Device	SNS	69__
	Output To Device	OUT	78__
5	Direct Input and Output	DIO	7A__
	Load Registers	LDR	89XY
	Load Registers and DAR+1	LDRP	8BXY
	Load DAR	LDD	84XY
	Load DAR and DAR+1	LDDP	86XY
10	Load Memory Indexed	LDI	8AO__
	Memory to I/O Device	MIO	8C__
	Memory to I/O Device and DAR+1	MIOP	8E__
	Load Link Register	LDL	8000 E
	Load Link Register and DAR+1	LDLP	8200 E
15	Load Absolute Address	LDA	9__
	Store Registers	ST	A9XY
	Store Registers and DAR+1	STRP	ABXY
	Store DAR	STD	A4XY
	Store DAR and DAR+1	STDP	A6XY
20	I/O Data To Memory	IOM	AC__
	I/O Data To Memory and DAR+1	IOMP	AE__
	Store Memory Indexed	STI	AAO__
	Store Link High Order (Even Byte)	SLH	A000
	Store Link High Order and DAR+1	SLHP	A200
25	Store Link Low Order (Odd Byte)	SLL	A100
	Store Link Low Order and DAR+1	SLLP	A300
	Store In Absolute Address	STA	B__

Equates - Control Microprocessor

The following equivalent expressions, that is, "equates", are used in connection with Control microprocessor program listings. These are used by
5 an Assembler to fill in a number for the English-type expressions.

	<u>Name</u>	<u>Definition</u>
	AUXCNT	Auxilliary Character Counter When Driving Right
10	CARPS	Rightmost Character Position for Present Density
	CD15	Character Density Equals 15 CPI
	CHACT	Character Count
	CHDEN	Density 15 CPI
15	CMDTA	Command Data Register
	CMREG	Command Register
	CMVAL	Command Validity Bit
	CPI15	(IN R1) 15 CPI Head Drive Speed
	CPOS	Rightmost Character Position
20	CPS10	Rightmost Character Position in Left Margin, 10 CPI
	CPS15	Rightmost Character Position in Left Margin, 15 CPI

Ecuates - Control Microprocessor (Continued)

	<u>Name</u>	<u>Definition</u>
	DNSCH	Density Change Flag
	DTNT	Forms Detent Speed
5	ECCH	(In R1) Echo Check in Data Register
	EMTT	Print Emitters and Motor Controls
	FCT1	Next Forms Command
	FEA	Forms Emitter A
	FEB	Forms Emitter B
10	FMCM	Forms Command Flag
	FRMCM	Forms Command
	FRMST	Forms Start Flag
	FWD	Forms Direction
	HIGST	Head Image Generator Is To Start
15	HLATCH	Saves Last Command To Head Motor
	LEFT	(In R1) Left Head Direction
	LOBYT	Forms Command, Low Byte
	MARGN	(IN R0) Margin Emitter
	ME10A	Maximum Emitter Count 10 CPI, High

Fcuates - Control Microprocessor (Continued)

	<u>Name</u>	<u>Definition</u>
	ME10B	Maximum Emitter Count 10 CPI, Low Byte
	ME15A	Maximum Emitter Count 15 CPI, High Nibble
5	ME15B	Maximum Emitter Count 15 CPI, Low Byte
	NCH10	Nominal Character Count, 10 CPI
	NCH15	Nominal Character Count, 10 CPI
	NE10A	Nominal Emitter Count, 10 CPI, High Nibble
	NE10B	Nominal Emitter Count, 10 CPI, Low Byte
10	NE15A	Nominal Emitter Count, 15 CPI, High Nibble
	NE15B	Nominal Emitter Count, 15 CPI, Low Byte
	NMEM1	High Nibble, Nominal Emitter Count
	NMEM2	Low Byte, Nominal Emitter Count
	NOMCH	Nominal Character Count
15	PARK	Ramp Command Flag
	PARTY	(In RO) Communications Atom Parity
	PRESY	(In RO) +Print Head Busy
	PRCMD	Print Command Flag

Equates - Control Microprocessor (Continued)

	<u>Name</u>	<u>Definition</u>
	PREM	(In RO) Print Emitter
	PRPND	Print Command Is Pending
5	PRRUM	(In R1) Print Head Run
	PRTCM	(In R1) Print Command
	RCVAL	Reset Command Validity
	RUN	Forms Run
	RV	Print Head Is Going Left (Reverse)
10	SAVE1	Temporary Storage Register
	TEST	Test Command
	TOK	Turn Around Is OK
	TRNAR	(In RO) Turn Around Emitter
	TSCMD	Test Command Flag
15	TSMDE	Test Mode Command
	TXBUF	Head Image Generator Is To Use Text Buffer 2
	TXTBF	Text Buffer 2
	USTIM	Microsecond Timer (3 USEC/Step)

Labels - Control Microprocessor

The following labels are used by the Control microprocessor. These serve, for example, as pointers for addressing or for branching purposes.

5	<u>Labels</u>	<u>Labels</u>
	ANALS	AN190
	AN010	AN200
	AN020	AN210
	AN030	ERREM
10	AN040	FORMS
	AN050	PCTRS
	AN060	PR400
	AN070	RG100
	AN080	RG105
15	AN090	RG107
	AN100	RG110
	AN110	RG115
	AN120	RG117
	AN130	RG118
20	AN140	RG120
	AN150	RG130
	AN160	RG140
	AN170	RG15
	AN180	RG150

Labels - Continued

	RG160
	RG165
	RG170
5	RG20
	RG30
	RG40
	RG50
	RG60
10	RG70
	RG80
	RG90
	RTMRG
	RTMR1
10	RTMR2
	RTMR3
	RTMR4
	RTMR5
	RTN
15	SSTRT
	TIME1
	TURN
	XAO
	XEF
20	XF0
	X9F

Program Listings

Program listings that relate to the flowcharts and operations described herein are presented below.

- 5 The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation.

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
10	X9F	EQU		10 CPI CHAR COUNT - 1 (159)
	XEF	EQU	+1	15 CPI CHAR COUNT - 1 (239)
		DC	X'9FEF'	
15	ANALS	EQU		ANALYSIS
		IN	CMREG	INPUT THE COMMAND REGISTER
		T	PARTY,I00	IS THE PARITY BIT ON
		BT	AN010	YES, GO SET UP TO RAMP
20		T	CMVAL,100	IS IT A VALID COMMAND
		BF	RTN	NO, RETURN TO CALLER
		M	R0,R2	MOVE COMMAND TO R2 AND R3
		N	1,R2	AND CLEAR PARITY AND VALIDITY BITS
25		M	R1,R3	
		T	ATVAL,I00	IS STATUS REG EMPTY
		BT	AN005	NO, BYPASS ECHO CHECK

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	IN	CMDTA	INPUT THE DATA REGISTER
	X	R2,R0	EXCLUSIVE OR THE CONTENTS
			OF
	X	R3,R1	THE COMMAND AND DATA REGS
	OUT	STDTA	OUTPUT IT TO THE CMA
10	M	ECCH,R1	TURN ON THE ECHO CHECK
			BIT
	M	X'0',R0	
	OUT	STREG	OUTPUT IT TO THE CMA
	AN005 IN	CMDTA	GET COMMAND DATA BACK
15	T	FRMCH,R3	IS IT A FORMS COMMAND
	BT	AN020	YES, GO SET UP FOR IT
	T	PRTCM,R3	IS IT A PRINT COMMAND
	BT	AN040	YES, GO SET UP FOR IT
	T	TEST,R2	IS IT A TEST COMMAND
20	BT	AN200	YES, GO SET UP FOR IT
	AN010 T	PRCMD+FMCMD+TSCMD,	
		CMDFL	IS A CMD BEING PERFORMED
	BT	RTN	YES, RETURN TO CALLER
	SBF	HHOME,PRERR	CLEAR HEAD HOME FLAG
25	SBN	PARK,PHF	SET THE RAMP COMMAND FLAG
	B	AN210	GO DO THE ECHO

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	AN020	T	FMCMDFL	IS THERE A FORMS COMMAND BEING PERFORMED
		BT	RTN	YES, RETURN TO CALLER
		T	LOBYT,R3	IS THIS THE LOW ORDER BYTE
10		BT	AN030	YES, GO HANDLE IT
		OUT	FCT1	STORE THE HIGH ORDER BYTE
		B	AN210	GO DO THE ECHO
	AN030	OUT	FCT2	STORE THE LOW ORDER BYTE
		SBN	FMCMDFL	SET THE FORMS COMMAND FLAG
15		SBN	FRMST,PHF	TURN ON FORMS START FLAG
		B	AN210	GO DO THE ECHO
	AN040	T	PRCMDFL	IS PRINT COMMAND FLAG ON
		BT	AN180	YES, GO AROUND
20		T	CHDEN,R3	IS DENSITY COMMAND 15 CPI
		BT	AN090	YES, CHECK IF IT WAS
		T	CD15,FLG1	WAS DENSITY 15 CPI
		BT	AN110	YES, GO RAMP THE HEADS

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	AN050	T	TXTBF,R3	IS TEXT BUFFER 2 ON
		BT	AN100	YES, GO TURN IT ON
		SBF	TXBUF,FLG1	TURN OFF THE TEXT BUFFER 2 FLAG
10	AN060	SBN	HIGST,FLG1	TURN ON HEAD IMAGE GENERATOR START
		SBN	PRCMD,CMDFL	TURN ON THE PRINT COMMAND FLAG
		SBF	PRPND,CMDFL	TURN OFF THE PRINT PENDING FLAG
15		SBF	DNSCH,PHF	TURN OFF THE DENSITY CHANGE FLAG
	AN070	T	CHDEN,R3	IS DENSITY COMMAND 15 CPI
		BT	AN080	YES, CONTINUE
20		T	X'1',R1	IS CHARACTER COUNT EVEN
		BF	AN080	YES, CONTINUE
		A	X'1',R1	MAKE THE CHARACTER COUNT EVEN
		AC	X'0',R0	
25	AN080	OUT	CHACT	STORE THE CHARACTER COUNT
		BAL	RTMRG	RIGHT MARGIN ROUTINE

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5		T	PRPND,CMDFL	IS PRINT PENDING
		BT	RTN	YES, RETURN TO CALLER
		B	AN210	GO DO THE ECHO
	AN090	T	CD15,FLG1	WAS DENSITY 15 CPI
		BF	AN190	NO, GO RAMP THE HEADS
10		B	AN050	GO CHECK THE TEXT BUFFER FLAG
	AN100	SBN	TXBUF,FLG1	TURN ON TEXT BUFFER 2 FLAG
		B	AN060	
15	AN110	IN	HLATCH	INPUT THE ACTUATOR MOTOR CONTROLS
		SBF	CPI15,R1	TURN OFF CPI15 ON THE MOTOR CONTROLS
		SBF	CD15,FLG1	TURN OFF THE 15 CPI FLAG
20	AN120	OUT	EMTT	OUTPUT THE MOTOR CONTROLS
		OUT	HLATCH	STORE IN STACK
		T	CD15,FLG1	WAS DENSITY 15 CPI
		BT	AN140	YES, GO SET UP FOR IT

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	IN	NE10A	INPUT NOM EMITT, HIGH BYTE FOR 10 CPI
	OUT	NMEM1	SAVE IT IN NOMINAL EMITTERS 1
	IN	NE10B	INPUT NOM EMITT, LOW BYTE FOR 10 CPI
10	OUT	NMEM2	SAVE IT IN NOMINAL EMITTERS 2
	IN	NCH10	INPUT NOM CHAR COUNT FOR 10 CPI
15	OUT	NOMCH	SAVE IT IN NOMINAL CHARACTER COUNT
	T	RV,FLG1	IS PRINT HEAD MOVING LEFT
	BT	AN130	YES, GO SET UP CHAR POSITION
20	IN	ME10A	INPUT HIGH BYTE OF MAX EMITTERS
	M	IO1,EMCT1	MOVE IT TO THE EMITTER COUNTER
	IN	ME10B	INPUT LOW BYTE OF MAX EMITTERS
25	M	IO0,EMCT2	MOVE IT TO THE EMITTER COUNTER
	M	IO1,EMCT3	MOVE IT TO THE EMITTER COUNTER
30	LDA	X9F	LOAD MAX CHAR POSITION FOR 10 CPI

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5		OUT	CPOS	SAVE IT IN CHARACTER POSITION
		IN	CPS10	INPUT NOM CHAR POS FOR 10 CPI
		OUT	CARPS	
10		B	AN160	GO SET DENSITY CHANGE FLAG
	AN130	IN	CPS10	INPUT NOM CHAR POS FOR 10 CPI
		OUT	CPOS	SAVE IT IN CHARACTER POSITION
15		OUT	CARPS	
		B	AN160	GO SET DENSITY CHANGE FLAG
	AN140	IN	NE15A	INPUT NOM EMITT, HIGH BYTE FOR 15 CPI
		OUT	NMEM1	SAVE IT IN NOMINAL EMITTERS 1
20		IN	NE15B	INPUT NOM EMITT, LOW BYTE FOR 15 CPI
		OUT	NMEM2	SAVE IT IN NOMINAL EMITTERS 2
25		IN	NCH15	INPUT NOM CHAR COUNT FOR 15 CPI
		OUT	NOMCH	SAVE IT IN NOMINAL CHARACTER COUNT

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flaas To
Perform The Operation (Continued)

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	T	RV,FLG1	IS PRINT HEAD MOVING LEFT
	BT	AN150	YES, GO SET UP CHAR POSITION
	IN	ME15A	INPUT HIGH BYTE OF MAX EMITTERS
10	M	IO1,EMCT1	MOVE IT TO THE EMITTER COUNTER
	IN	ME15B	INPUT LOW BYTE OF MAX EMITTERS
	M	IO0,EMCT2	MOVE IT TO THE EMITTER COUNTER
15	M	IO1,EMCT3	MOVE IT TO THE EMITTER COUNTER
	LDA	XEF	LOAD MAX CHAR POSITION FOR 15 CPI
20	OUT	CPOS	SAVE IT IN CHARACTER POSITION
	IN	CPS15	INPUT NOM CHAR POS FOR 15 CPI
	OUT	CARPS	
	B	AN160	GO SET DENSITY CHANGE FLAG
25			

The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	AN150	IN	CPS15	INPUT NOM CHAR POS FOR 15 CPI
		OUT	CPOS	SAVE IT IN CHARACTER POSITION
		OUT	CARPS	SAVE IT
10	AN160	SEN	DNSCH,PHF	SET THE DENSITY CHANGE FLAG
		RTN	,	RETURN TO CALLER
	AN170	T	CD15,FLG1	WAS DENSITY 15 CPI
		BF	AN160	NO, SET THE DENSITY CHANGE FLAG
15		B	AN070	YES, GO COMPUTE RIGHT MARGIN
	AN180	SEN	PRPND,CMDFL	TURN ON PRINT COMMAND PENDING FLAG
20		T	RV,FLG1	IS PRINT HEAD MOVING LEFT
		BT	RTN	YES, RETURN TO CALLER
		T	CHDEN,R3	IS DENSITY COMMAND 15 CPI
		BT	AN170	YES, CHECK IF IT WAS
		T	CD15,FLG1	WAS DENSITY 15 CPI
25		BF	AN070	NO, GO COMPUTE RIGHT MARGIN

BAD ORIGINAL



The Routine Reads The Command And Data Latches,
Analyzes The Contents And Sets The Proper Flags To
Perform The Operation (Continued)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5		B	AN160	YES, GO AROUND
	AN190	IN	HLATCH	INPUT THE ACTUATOR MOTOR CONTROLS
		SBN	CPI15,R1	TURN ON CPI 15 ON THE MOTOR CONTROLS
10		SBN	CD15,FLG1	TURN ON THE 15 CPI FLAG
		B	AN120	GO OUTPUT ACTUATOR CONTROLS
	AN200	OUT	TSMDE	SAVE IT
		SBN	TSCMD,CMDFL	TURN ON TEST COMMAND FLAG
	AN210	OUT	RCVAL	RESET COMMAND VALIDITY BIT
15	RTN	RTN	,	RETURN TO CALLER
		HIGC1		INSERT HIG MACRO

Right Margin Routine

This routine is entered whenever it is necessary to determine where right margin is.

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	RTMRG EQU		RIGHT MARGIN ROUTINE
	IN	NOMCH	INPUT NOMINAL CHARACTER COUNT
	M	R0,R2	MOVE R0 TO R2
	M	R1,R3	MOVE R1 TO R3
10	IN	NMEM1	INPUT HIGH NIBBLE OF THE NOMINAL EMITTER
	M	R1,D0	COUNT AND SAVE IT IN D0
	IN	NMEM2	INPUT LOW BYTE OF THE NOMINAL EMITTER
15	M	R0,D1	COUNT AND SAVE IT IN D1 AND D2
	M	R1,D2	
	IN	CHACT	INPUT COMMANDED CHARACTER COUNT
20	C	R0,R2	IS COMMANDED LESS OR EQUAL TO NOMINAL
	BH	RTMR3	NO, GO FIND NEW RIGHT MARGIN
	BE	RTMR5	GO CHECK LOW NIBBLE IF ITS EQUAL
25			

BAD ORIGINAL



Right Margin Routine (Cont'd.)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	RTMR1	C	D0, RM1	IS HIGH NIBBLE OF NEW RIGHT MARGIN
5		BH	RTMR2	GREATER THAN PRESENT RIGHT MARGIN
		BNE	RTN	IS IT LESS
		C	D1, RM2	IS THE MIDDLE NIBBLE GREATER
10		BH	RTMR2	YES, GO SET THE NEW RIGHT MARGIN
		BNE	RTN	IF LESS, LEAVE OLD RIGHT MARGIN
		C	D2, RM3	IS THE LOW NIBBLE GREATER
15		BLE	RTN	YES, LEAVE THE OLD RIGHT MARGIN
	RTMR2	M	D0, RM1	MOVE THE NEW RIGHT MARGIN EMITTER COUNT
		M	D1, RM2	INTO THE RIGHT MARGIN REGISTERS
20		M	D2, RM3	
		RTN	,	RETURN TO CALLER
	RTMR3	S	R3, R1	SUBTRACT THE NOMINAL FROM THE COMMANDED
25		SB	R2, R0	CHARACTER COUNT

Right Margin Routine (Cont'd.)

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	M	R1,R4	SETUP THREE REGISTERS TO MULTIPLY
5	M	R0,R3	THE RESULTS
	M	X'0',R2	
	OUT	SAVE1	SAVE THE RESULTS OF THE SUBTRACT
	M	X'3',R0	SET THE LOOP COUNTER
10	RTMR4 A	R4,R4	MULTIPLY THE RESULTS OF THE SUBTRACT
	AC	R3,R3	BY 8
	AC	R2,R2	
	S	X'1',R0	DECREMENT THE LOOP COUNTER
15	BNZ	RTMR4	
	IN	SAVE1	RESTORE THE RESULTS OF THE SUBTRACT AND
	A	R1,R4	ADD IT TO THE RESULTS OF THE MULTIPLY
20	AC	R0,R3	BY 8
	AC	X'0',R2	THIS IS THE SAME AS MULTIPLYING BY 9
	A	R4,D2	ADD THE RESULTS TO THE NOMINAL
25	AC	R3,D1	EMITTER COUNT
	AC	R2,D0	
	B	RTMR1	GO CHECK THIS AGAINST PRESENT RIGHT MARG

Right Margin Routine (Cont'd.)

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
5	RTMR5 C	R1,R3	IS LOW NIBBLE GREATER
	BH	RTMR3	YES, GO FIND NEW RIGHT MARGIN
	B	RTMR1	GO CHECK THE NEW AGAINST THE PRESENT
	FORC1		INSERT FORMS CONTROL ROUTINE

10 Head Moving Right In Print Area; Printing Complete

This routine is entered when printing is complete and the print heads were moving to the right.

Get and Save the Print Emitters

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
15	RG10 IN	EMTT	GET THE EMITTERS
	SBF	PRBSY,IOO	MASK OFF BUSY BIT
	M	IOO,PEMT	MOVE EMITTERS TO SAVE REGISTER
	SBF	TOK,FLG2	RESET TURN AROUND FLAG
20	S	1,WIPOS	SUBTRACT ONE FROM WIRE POSITION
	SBF	HATNA,PRERR	CLEAR HEAD AT TURNAROUND FLAG

Increment the Emitter Counters

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	A	1,EMCT3	ADD ONE
	AC	0,EMCT2	TO THE
5	AC	0,EMCT1	EMITTER COUNTERS

Adjust the Position

<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	IN	CPOS	GET RIGHTMOST CHARACTER POSITION
10	S	X'1',IO1	SUBTRACT 1 FROM IT
	SB	0,IO0	
	OUT	AUXCNT	STORE IN AUX COUNTER
RG15	T	DNSCH,PHF	DID DENSITY CHANGE?
15	BT	PR400	BRANCH IF YES (DRIVE HEADS TO MARGIN)

Set the Timer For 625 Micro Seconds

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
		LDA	TIMe1	GET HEX 625 MICRO SECONDS
		OUT	USTIM	LOAD THE TIMER
5		T	FRMST,PHF	IS FORMS START ON
		BF	RG20	BRANCH IF NOT
		BAL	SSTRT	ELSE GO START THE FORMS
	RG20	BAL	FORMS	FORMS CONTROL ROUTINE
		T	TOK,FLG2	IS TURN AROUND FLAG ON?
10		BT	RG30	BRANCH IF YES
		T	PRPND,CMDFL	IS THERE A PRINT COMMAND PENDING?
		BT	RG28	BRANCH IF THERE IS
		T	PRCMD,CMDFL	DO WE HAVE A PRINT COMMAND?
15		BF	RG70	BRANCH IF NOT

Is Head Far Enough Right To Turn Around?

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	RG25	M	EMCT3,R3	MOVE EMITTER COUNT TO WORK REG
5		M	EMCT2,R2	
		M	EMCT1,R1	
		S	RM3,R3	SUBTRACT RIGHT MARGIN VALUE
		SB	RM2,R2	
10		SB	RM1,R1	
		BNC	RG30	BRANCH IF EM CT >= RIGHT MARG
	RG28	SBN	TOK,FLG2	TURN ON TURNAROUND FLAG
	RG30	IN	USTIM	GET THE TIMER
15		T	X'C',100	ENOUGH TIME TO RUN FORMS?
		BF	RG80	BRANCH IF NOT
		BAL	FORMS	FORMS CONTROL ROUTINE
		B	RG30	LOOP AS LONG AS TIME REMAINS

Go See If There Is Another Command And Density Change

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	RG70	BAL	ANALS	ANALYSIS ROUTINE
5		T	DNSCH,PHF	WAS THERE A DENSITY CHANGE?
		BF	RG30	BRANCH IF NOT
		B	PR400	ELSE DRIVE HEADS TO MARGIN

Update Timer For 10 Or 15 CPI

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
10	RG80	T	CD15,FLG1	ARE WE AT 15 CPI?
		BF	RG100	BRANCH IF NOT
		IN	USTIM	GET THE TIMER
		A	6,I01	ADD 450 MICRO SECONDS
15		AC	9,I00	
		OUT	USTIM	STORE THE RESULTS IN THE TIMER

Check If There Is Enough Time To Run Forms

	<u>Label</u>	<u>Op Code</u>	<u>Arquments</u>	<u>Comment</u>
	RG90	IN	USTIM	GET THE TIMER
		T	X'C',IO0	IS THERE ENOUGH TIME?
		BF	RG100	BRANCH IF NOT ENOUGH TIME
5		BAL	FORMS	FORMS CONTROL ROUTINE
		B	RG90	LOOP IF ENOUGH TIME
	RG100	IN	USTIM	GET THE TIMER
		A	8,IO1	ADD 600 MICRO SECONDS
		AC	X'C',IO0	
10		BC	RG100	LOOP IF OVERFLOW
		OUT	USTIM	STORE THE RESULTS IN THE TIMER
	RG105	BAL	FORMS	FORMS CONTROL ROUTINE
		IN	EMTT	READ PRINT EMITTERS
15		T	TOK,FLG2	IS TURNAROUND FLAG ON?
		BT	RG120	BRANCH IF ON

Check If There Is Enough Time To Run Forms (Cont'd.)

	<u>Label</u>	<u>Op Code</u>	<u>Arquments</u>	<u>Comment</u>
	RG107	T	PREM,IO0	IS PRINT EMITTER ON
		BF	RG110	BRANCH IF NOT ON
5		IN	EMTT	READ PRINT EMITTERS
		T	PREM,IO0	IS PRINT EMITTER ON?
		BT	RG140	BRANCH IF ON
	RG110	M	IO0,PEMT	SAVE THE EMITTER READINGS
		T	MARGN,IO0	IS MARGIN ON?
10		BT	RG115	BRANCH IF ON
		IN	USTIM	GET THE TIMER
		BNZ	RG105	BRANCH IF NOT ZERO
		B	ERREM	ERROR

Head At Right Margin, Set Character Count To Max

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	RG115	T	CD15,FLG1	ARE WE AT 15 CPI
		BT	RG117	YES, SET UP COUNT FOR 15
5		LDA	XA0	SET UP COUNT FOR 10
		B	RG118	
	RG117	LDA	XF0	LOAD COUNT FOR 15
	RG118	OUT	AUXCNT	STORE CHARACTER COUNT
		B	RG130	GO STOP THE HEAD MOTOR
10	XF0	EQU		15 CPI MAX CHARACTER COUNT
	XA0	EQU	1	10 CPI MAX CHAR COUNT
		DC	A(X'F0A0')	
15	RG120	M	IO0,REG2	MOVE EMITTERS TO REG 2
		X	PENT,REG2	DID TURNAROUND EMITTER CHANGE
		T	TRNAR,REG2	
		BF	RG107	BRANCH IF NO CHANGE

Set Head Stopped At Turnaround Flag

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
		SBN	HATNA,PRERR	TURN ON FLAG
		SBF	EDGE,PRERR	CLEAR EDGE FLAG
5		N	TRNAR,IO0	CLEAR ALL BUT TURNAROUND EMITTER
		O	IO0,PRERR	OR INTO FLAG

Motor Controls (Stopping)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
10	RG130	IN	HLATCH	GET MOTOR CONTROLS
		SBF	RRUN,IO1	TURN OFF RUN
		SBN	LEFT,IO1	TURN ON LEFT
		OUT	EMTT	OUTPUT MOTOR CONTROLS
		OUT	HLATCH	STORE IN STACK
15		IN	CPOS	GET RIGHT MOST CHAR POSITION
		S	1,IO1	SUBTRACT ONE
		SB	0,IO0	
		OUT	CPOS	STORE IT
20		IN	AUXCNT	GET AUX CHAR COUNTER
		OUT	CHACT	STORE IN CHARACTER COUNTER
		BAL	RIMRG	RIGHT MARGIN ROUTINE

Move Margin Count To Emitter Count

<u>Label</u>	<u>Op Code</u>	<u>Arquments</u>	<u>Comment</u>
	M	RM3,EMCT3	MOVE RIGHT
	M	RM2,EMCT2	MARGIN COUNT TO
5	M	RM1,EMCT1	EMITTER COUNT
	M	0,PT1	CLEAR FORMS COMMAND COUNTER
	T	HATNA,PRERR	DID HEAD STOP AT TURN- AROUND EMI
10	BF	PCTRS	BRANCH IF NO
	LDA	HEX0D	SET TIMER TO 20
	OUT	MSTIM	MILLISECONDS
	B	PC020	RETURN TO MAJOR LOOP
RG135	BAL	FORMS	GO TO FORMS ROUTINE
15	IN	MSTIM	GET THE TIMER
	BNZ	RG135	LOOP IF NOT ZERO
	B	PCTRS	RETURN TO MAJOR LOOP
RG140	T	CD15,FLG1	ARE WE AT 15 CPI?
	BT	RG150	BRANCH IF YES
20	M	2,REG2	PUT A TWO IN REG TWO
	B	RG160	JUMP OVER NEXT INSTRUCTION

Move Margin Count To Emitter Count (Cont'd.)

	<u>Label</u>	<u>Op Code</u>	<u>Arguments</u>	<u>Comment</u>
	RG150	M	3,REG2	PUT A THREE IN REG 2
	RG160	IN	CPOS	GET RIGHTMOST CHAR POSITION
5		S	REG2,WIPOS	SUBTRACT REG2 FROM WIPOS
		BNC	RG170	BRANCH IF NO CARRY
		BZ	RG170	BRANCH IF ZERO
	RG165	A	REG2,EMCT3	ADD REG TWO TO EMITTER COUNTER
10		AC	0,EMCT2	
		AC	0,EMCT1	
		B	RG15	
	RG170	A	9,WIPOS	ADD NINE TO WIRE POSITION
		A	1,IO1	INCREMENT CHAR POSITION
15		AC	0,IO0	PLUS ONE
		OUT	CPOS	AND STORE RESULTS
		IN	AUXCNT	GET THE CHARACTER COUNT
		A	1,IO1	INCREMENT IT
		AC	0,IO0	PLUS ONE
20		OUT	AUXCNT	STORE IN AUX COUNTER
		B	RG165	
	REG2	EQU	R2	
	TIME1	DC	X'D000'	
		ANLC1		INSERT ANALYSIS MACRO

CLAIMS

1. Partial line turnaround device for a printer, provided with forms assembly means for moving a form for printing at a print line, a wire matrix print assembly
5 incorporating print wires and print wire actuators arranged in print heads spaced at regular predetermined intervals, said print assembly being mounted for reciprocal printing movement along said print line, and wire image means for providing signals on a selective
10 basis to activate said print wire actuators to produce characters by means of dots on said forms during printing operations, said signals being supplied to said print assembly as it moves along said print line.

This line turnaround device is characterized in that it comprises :

15 turnaround input means (232, 210) for producing signals indicative of the number of print heads in said print assembly, the character density, the print head spacing, and the starting point of the last print head in
20 said print assembly;

margin means (211) responsive to signals from said turnaround input means for producing signals indicative of selected stopping and turnaround input means for
25 producing signals indicative of selected stopping and turnaround points for said print assembly in individual lines to be printed;

means responsive (234, 235) to Print Commands to move said print assembly along said print line in order to print characters in individual lines of printing;

30 emitter means (236) operable during movement of said print head assembly along said print line to provide signals indicative of the positional location of said

print assembly and for defining successive stopping and turnaround points in a line of printing in said printer unit during printing operations;and

5 turnaround control means (232, 210, 234, 235) responsive to signals from said margin means and said emitter means to control stopping and turnaround of said print assembly.

2. Partial line turnaround device according to claim 1
10 characterized in that the emitter means are structured to provide dot matrix location emitters (71A, 72), turnaround emitters (71B, 72), margin emitters (71C, 72), and other emitters, the physical dimensions of said emitter means being of different lengths dependent upon the physical head spacing of the print heads,
15 longer emitter means being used for fewer print heads and conversely.

3. Partial line turnaround device according to claim 2
20 characterized in that the turnaround emitters (71B, 72) comprise turnaround emitter areas spaced at distances that are correlated with the spacing of the characters in individual print lines.

4. Partial line turnaround device according to claim 1, 2
25 or 3 characterized in that print assembly has print wires arranged in groups (77) of two, four, six, or eight print heads arranged in parallel from left to right relative to the print lines, each print head comprising eight print wires (33).

5. Partial line turnaround device according to claim 4
30 characterized in that the print wires (33) are spaced two character locations apart and wherein said turnaround areas (71B) are also spaced two character locations apart at 10 characters per inch, three character loca-

tions apart at 15 characters per inch.

- 5 6. Partial line turnaround device according to any of the preceding claims characterized in that the line turnaround means (215, 210, 232, 234, 235) processes factors and makes turnaround decisions with respect to a right margin area only.
- 10 7. Partial line turnaround device according to claim 6 characterized in that the right margin area is defined for each print line as it is received and independently of the other print lines preceding or succeeding it.
- 15 8. Partial line turnaround device according to any of the preceding claims characterized in that it comprises a microprocessor (210) associated with said printer unit, said microprocessor performing calculations utilizing the line turnaround factors product by the turnaround input means and the emitter means to determined optimum line turnaround and monitoring movement of the print assembly in order to determine the points of turnaround required during printing of individual print lines.
- 20 9. Partial line turnaround device according to claim 8 characterized in that :

the microprocessor (210) conducts a right margin calculation for each line of characters printed during printing operations, and

25 stores counts representative of optimum line turnaround factors.
10. Partial line turnaround device according to any of the preceding claims characterized in that it further comprises :

means (210, 234, 235) for moving said print assembly at a slower rate for character printing of greater density such as 15 characters per inch and at a relatively faster rate for characters of less density, such as 10 characters per inch.

11. Partial line turnaround device according to any of the preceding claims characterized in that:

a host data processing system (1), provides both control and data signals to said printer for use during printing operations.

12. Partial line turnaround device for a printer, provided with a printer unit incorporating forms assembly means for moving a form for printing at a print line, a wire matrix print assembly incorporating print wires and print wire actuators arranged in print heads spaced at regular predetermined intervals, said print assembly being mounted for reciprocal printing movement along said print line and wire image means for providing signals on a selective basis to said printer unit to activate said print wire actuators to produce characters by means of dots on said forms during printing operations, said signals being supplied to said print assembly as it moves along said print line,

This partial line turnaround device is characterized in that it comprises :

turnaround input means (232, 210) for producing signals indicative of the number of print heads in said print assembly, the character density, the print head spacing, and the starting point of the last print head in said print assembly;

margin means (211) responsive to signals from said

turnaround input means for producing signals indicative of selected stopping and turnaround points for said print assembly in individual lines to be printed; said individual lines of printing being categorized into a plurality of defined line lengths and said turnaround control means being operable in accordance with the following definitions :

- (1) Definition of less than nominal line and its STOP formula:

$$\begin{aligned} \text{CHCT} &< (\text{HDSP}) (\text{CPI}) \\ \text{STOP} &= (\text{CHCT}) + (\text{HDSP}) (\text{CPI}) (\# \text{HD} - 1) + \\ &\quad (\text{K}) (\text{CPI}) \end{aligned}$$

- (2) Definition of nominal line length and its STOP formula:

$$\begin{aligned} \text{CHCT} &< (\# \text{HD}) (\text{HDSP}) (\text{CPI}) - (\text{K}) (\text{CPI}) \\ \text{STOP} &= (\text{K}) (\text{CPI}) + (\text{HDSP}) (\text{CPI}) (\# \text{HD}), \end{aligned}$$

- (3) Extended line printing is anything not covered by 1 or 2 but does have its own STOP formula:

$$\text{STOP} = (\text{CHCT}) + (\text{K}) (\text{CPI}) (2),$$

wherein CHCT = Character Count,

HDSP = Head Spacing,

CPI = Characters per inch,

K = Constant representing the

distance between print wires at

extremities of each print head, and

STOP = the print position the last

print head must print to complete a

given character count;

means (234, 235) responsive to Print Commands to move said print assembly along said print line in order to print characters in individual lines of printing;

5 emitter means (236) operable during movement of said print head assembly along said print line to provide signals indicative of the positional location of said print assembly and for defining successive stopping and turnaround points in a line of printing in said printer unit during printing operations;

10 and

turnaround control means (232, 210, 234, 235) responsive to signals from said margin means and said emitter means to control stopping and turnaround of said print assembly.

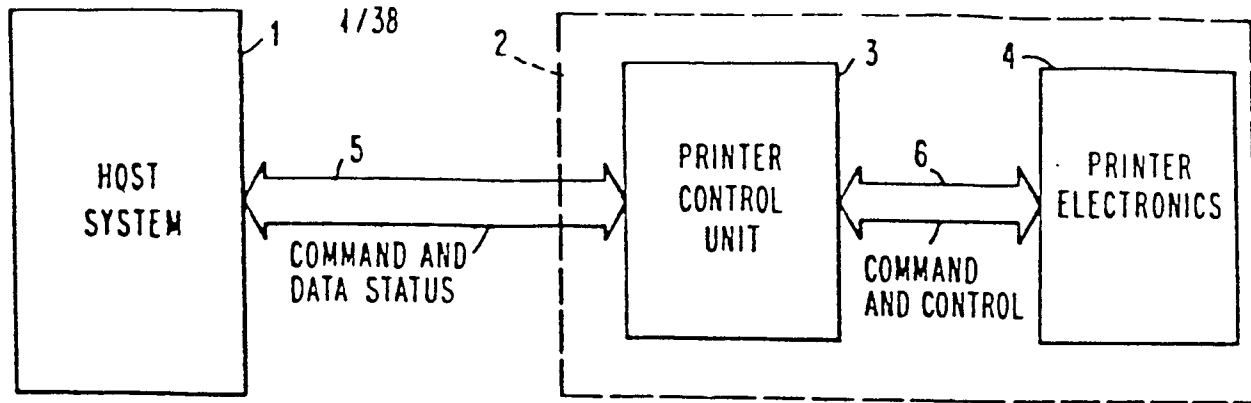


FIG. 1

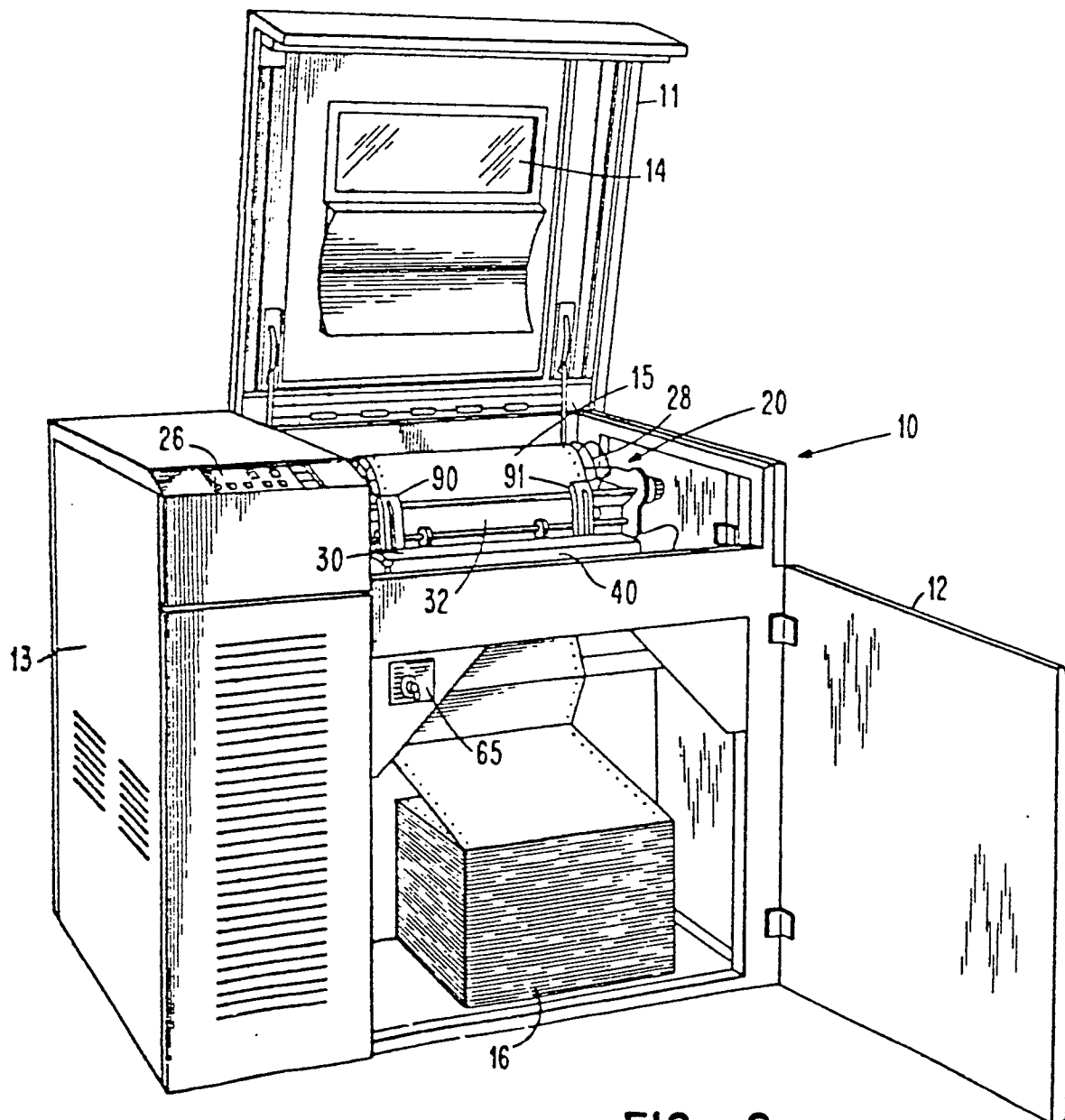


FIG. 2

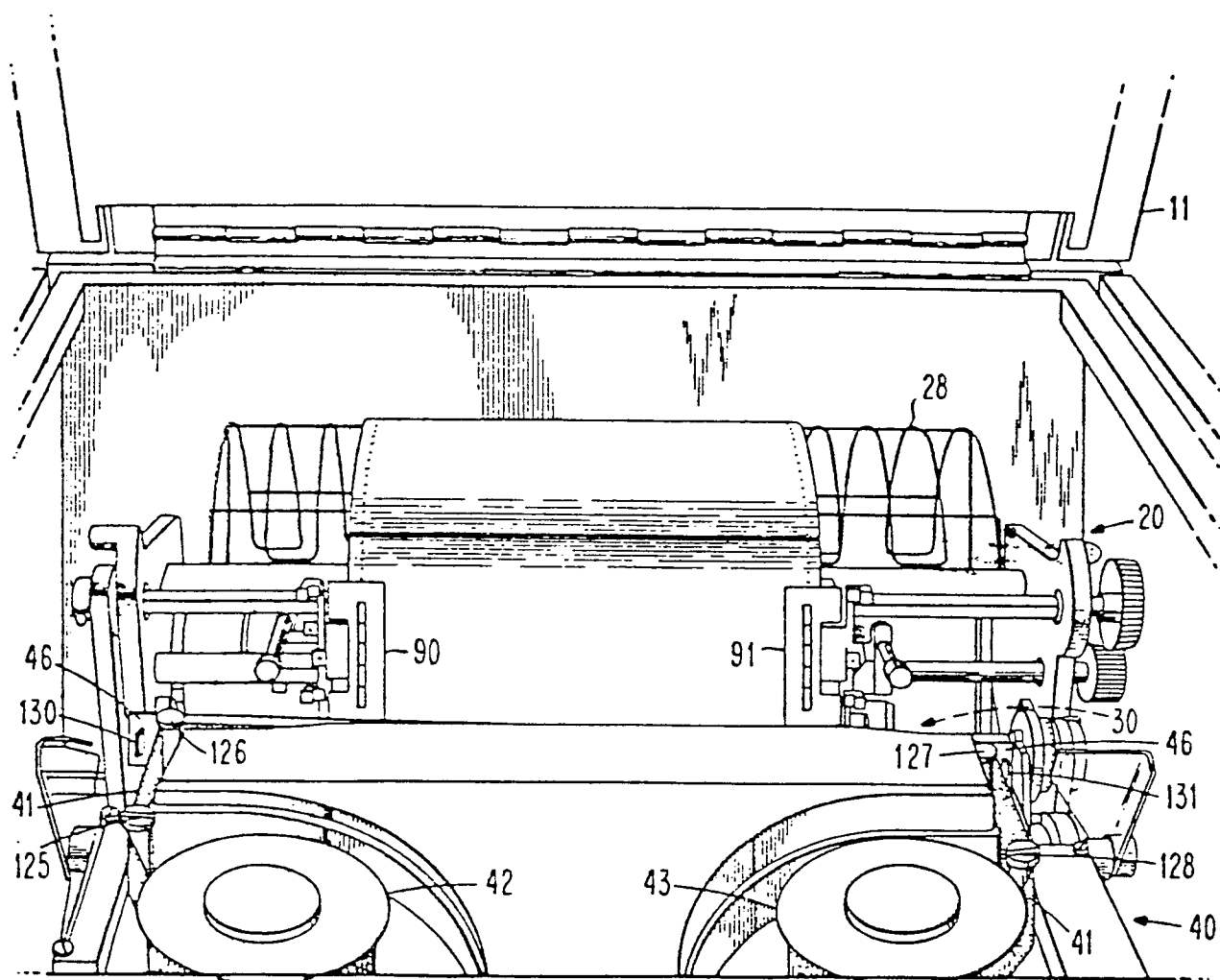
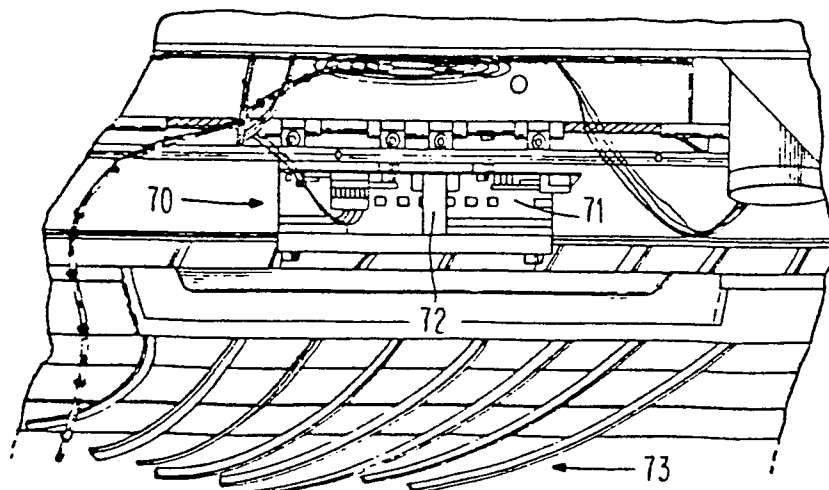
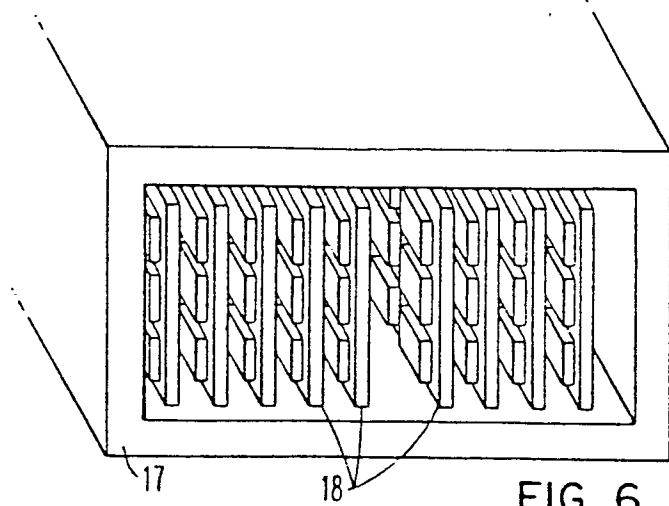
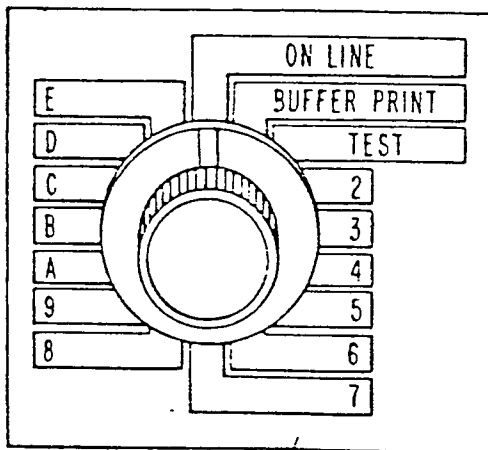
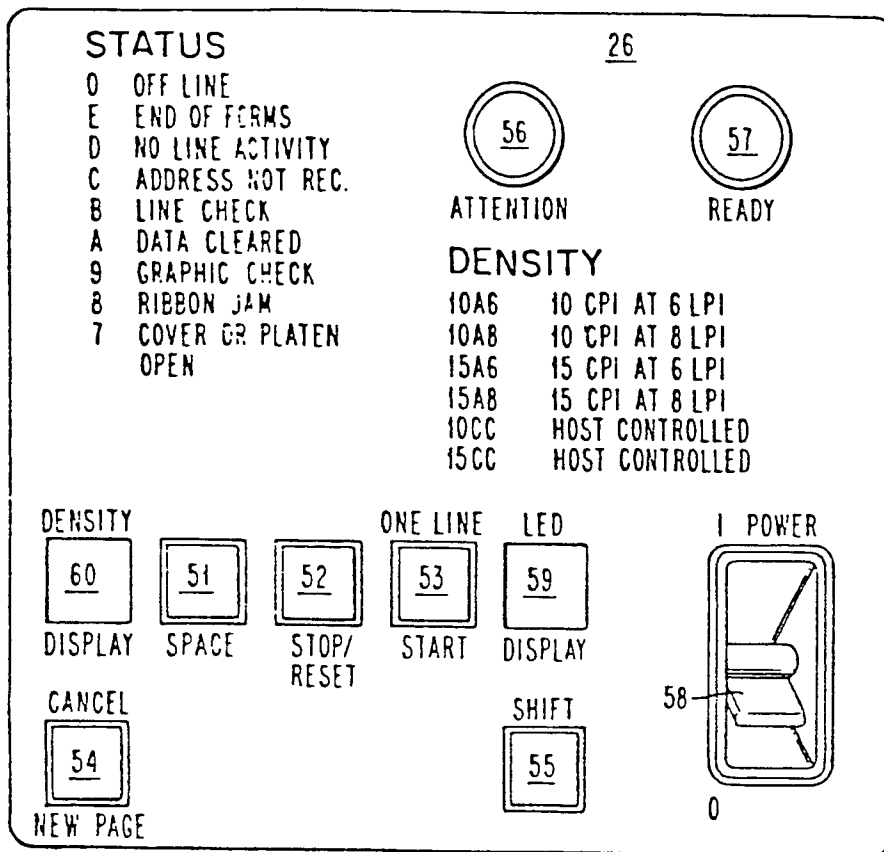
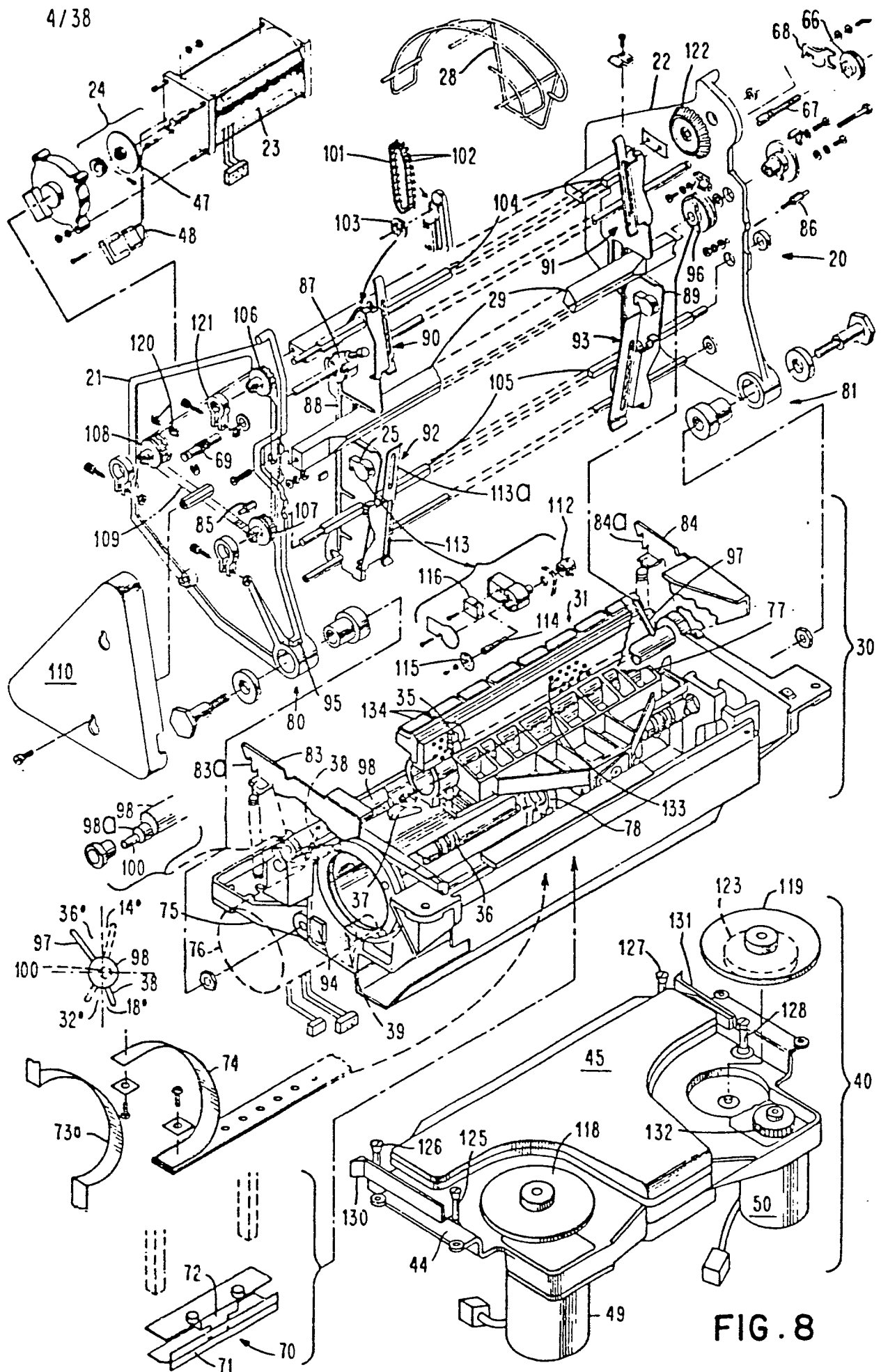


FIG. 3





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FIG. 9

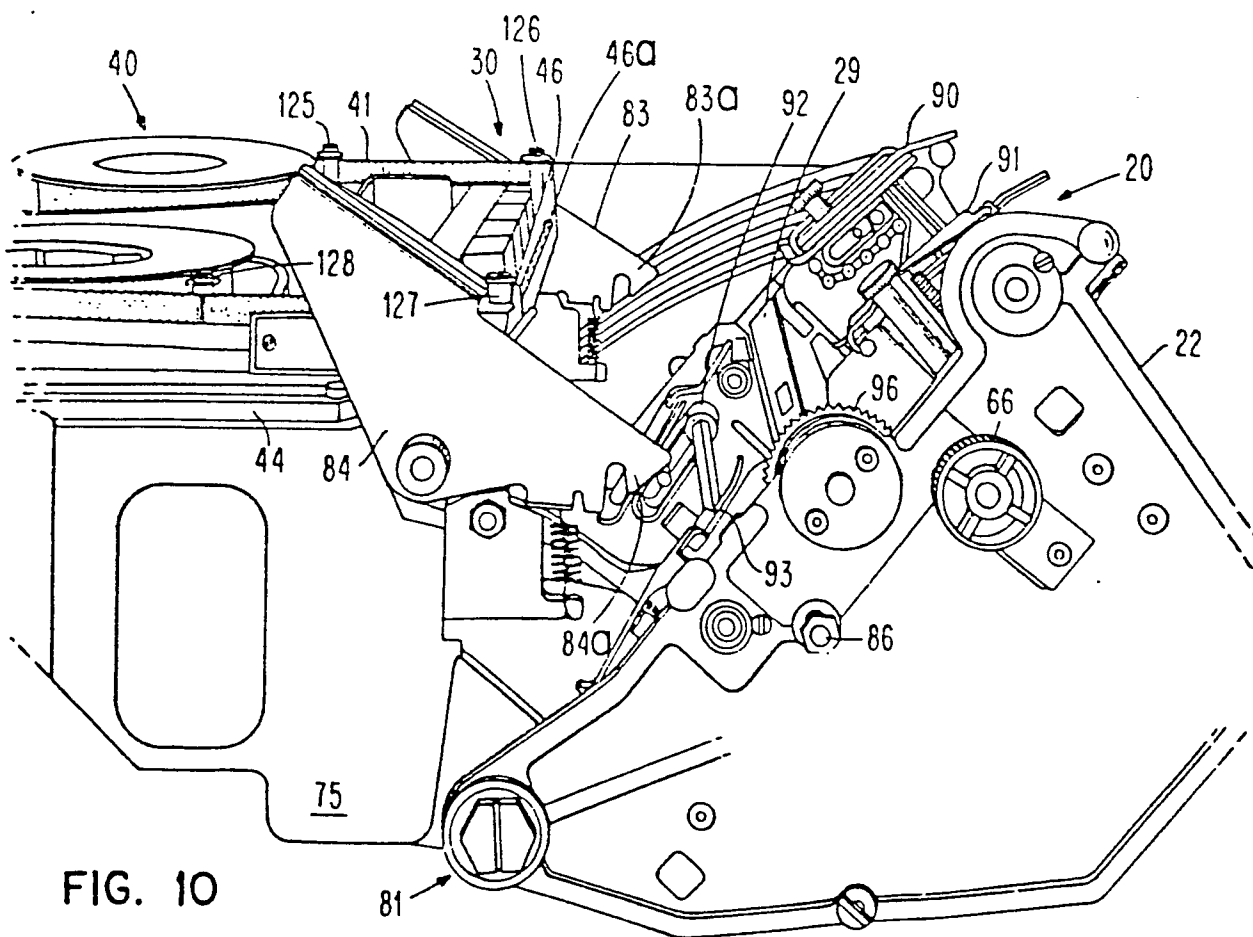
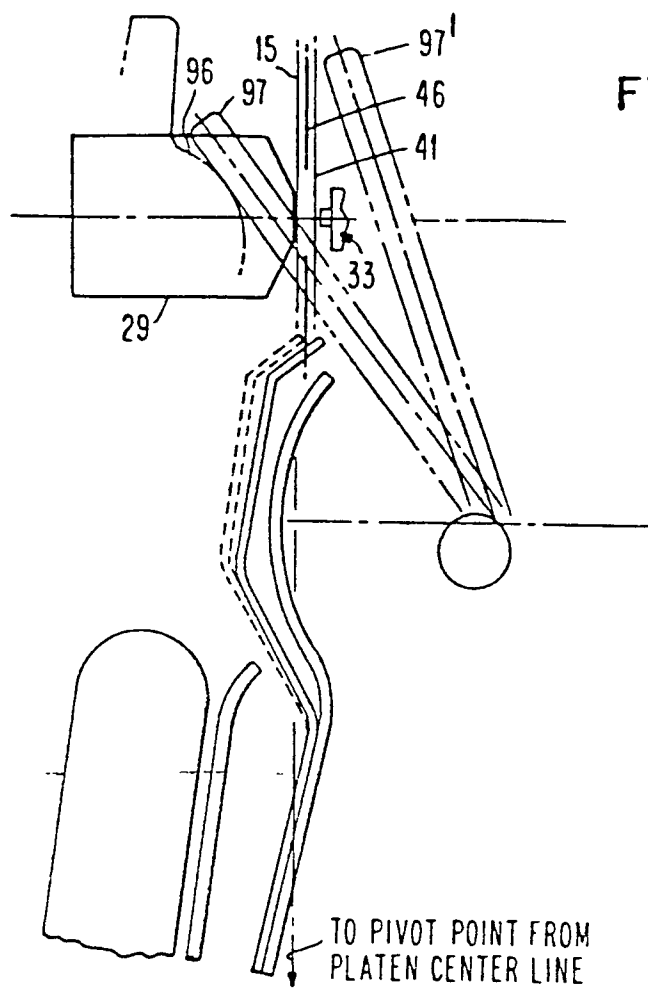
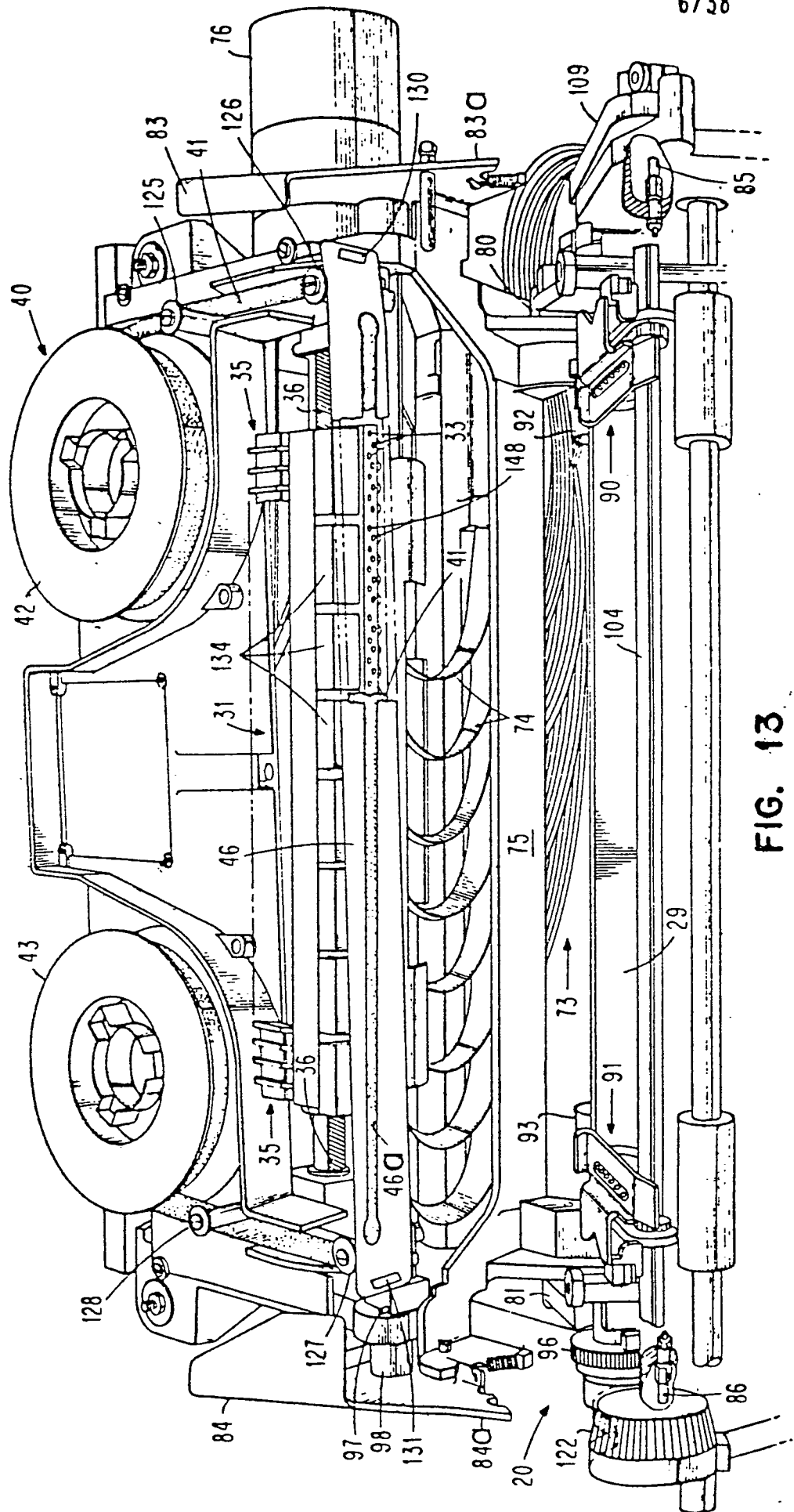
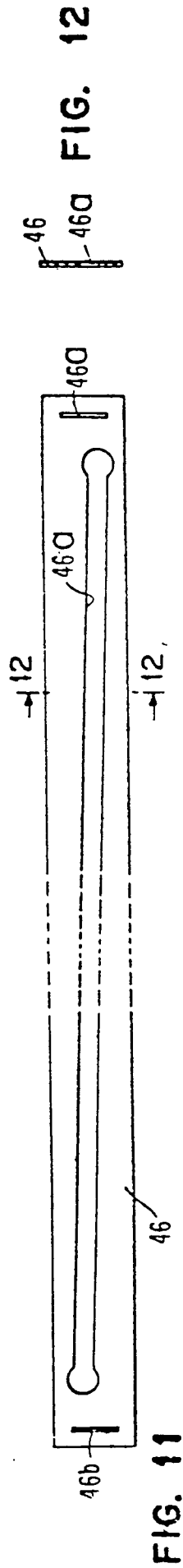
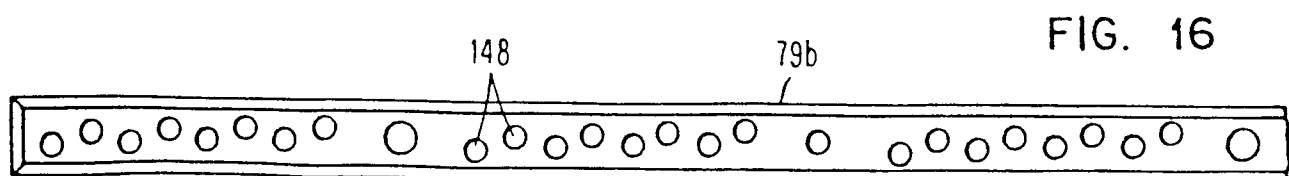
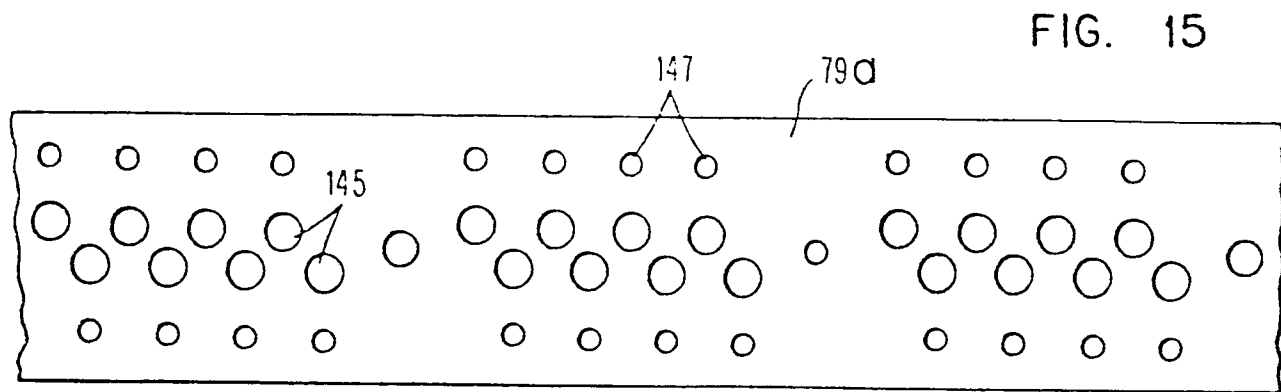
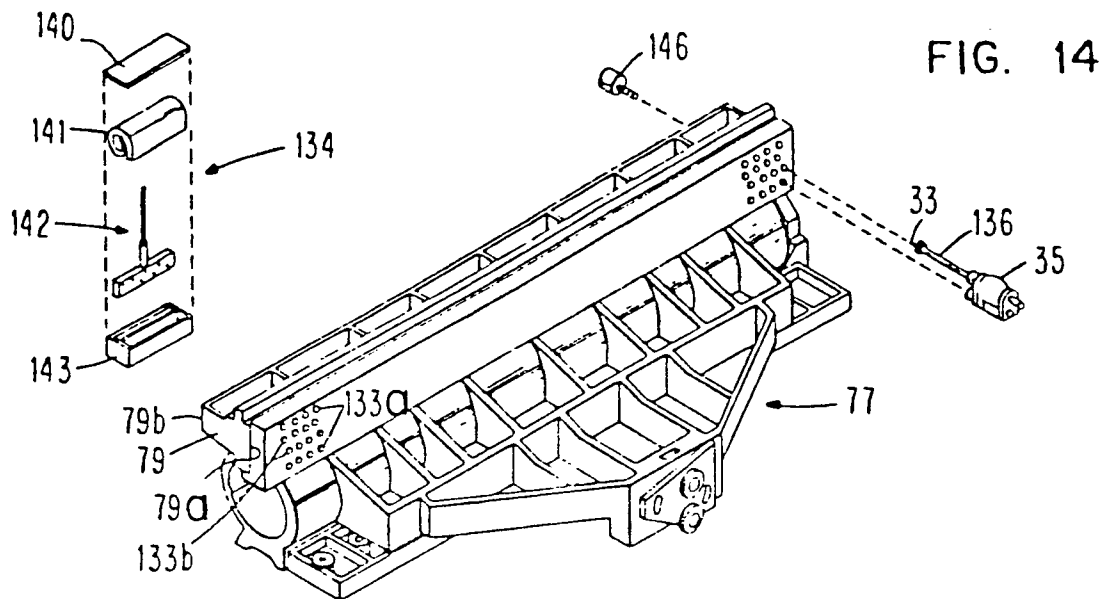


FIG. 10





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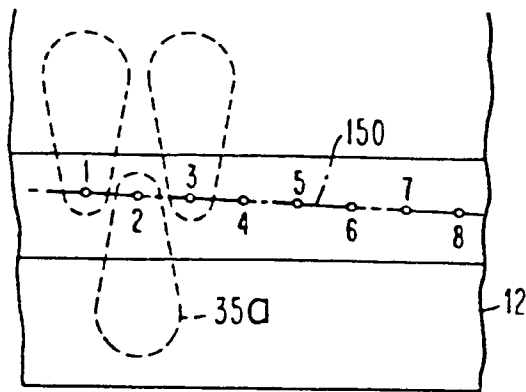


FIG. 17

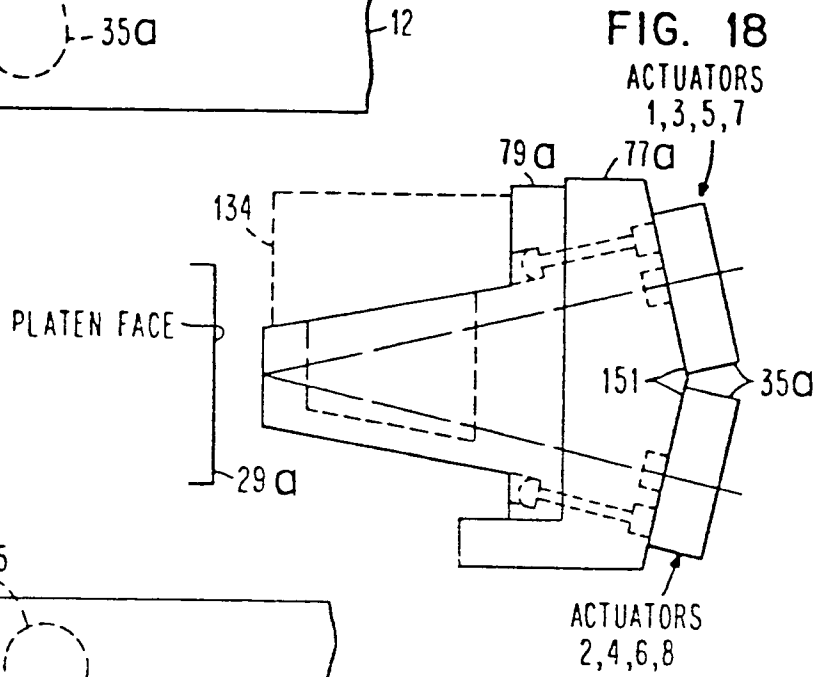


FIG. 18

FIG. 19

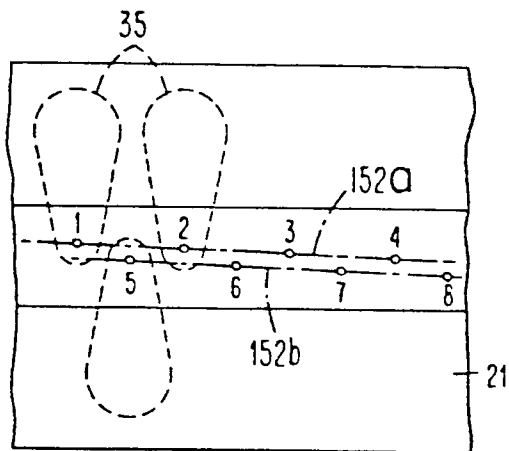
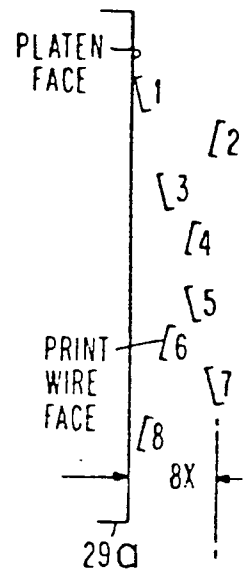


FIG. 20

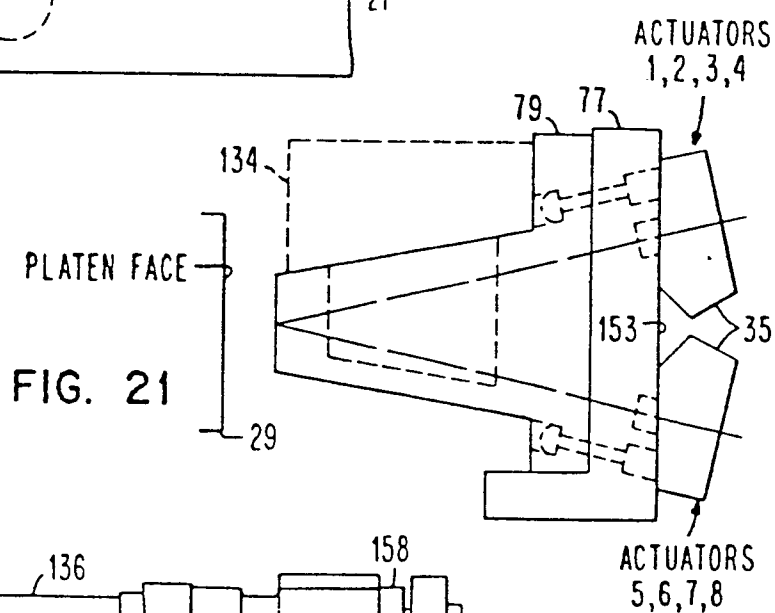


FIG. 21

FIG. 22

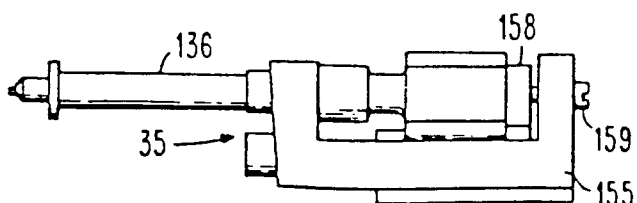
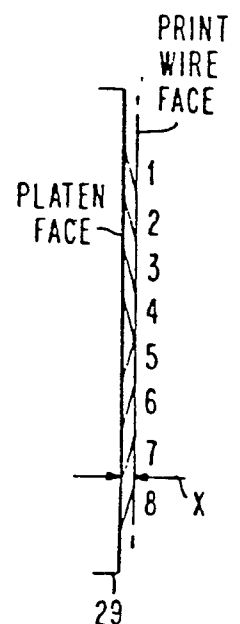
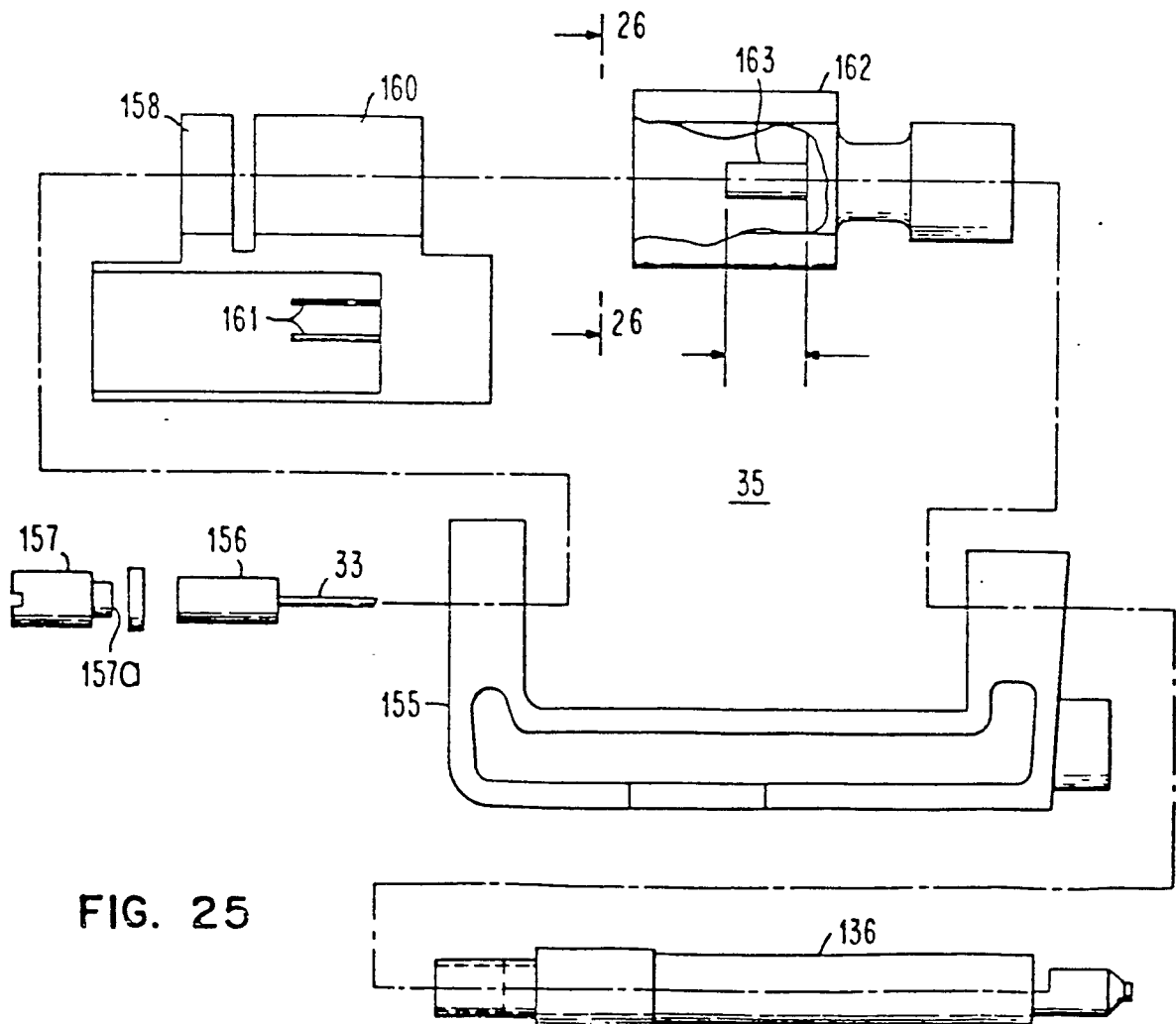
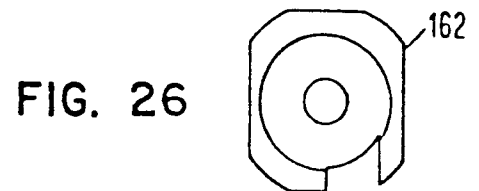
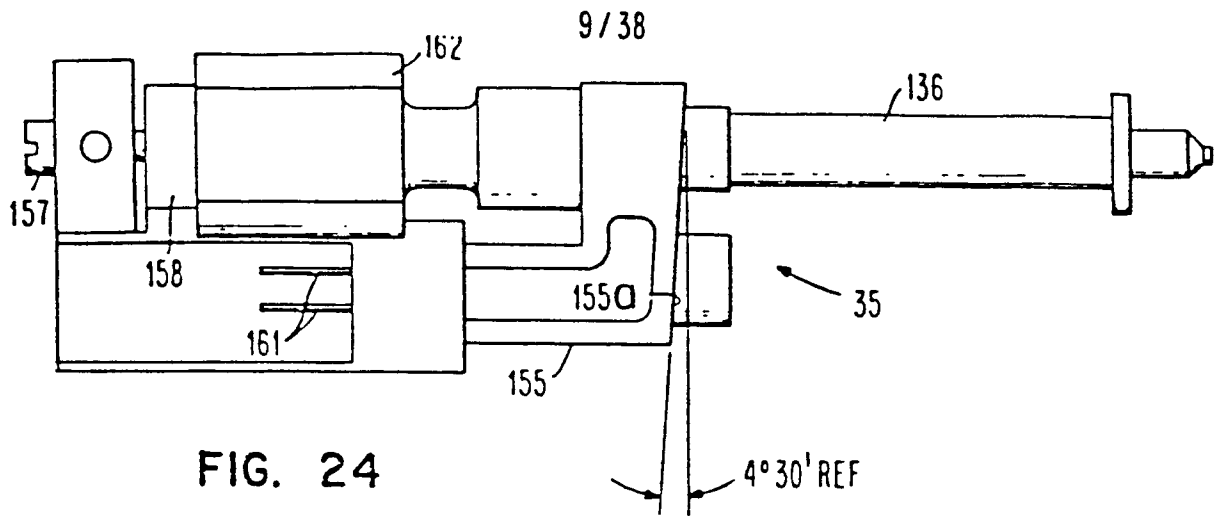


FIG. 23



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FIG. 27

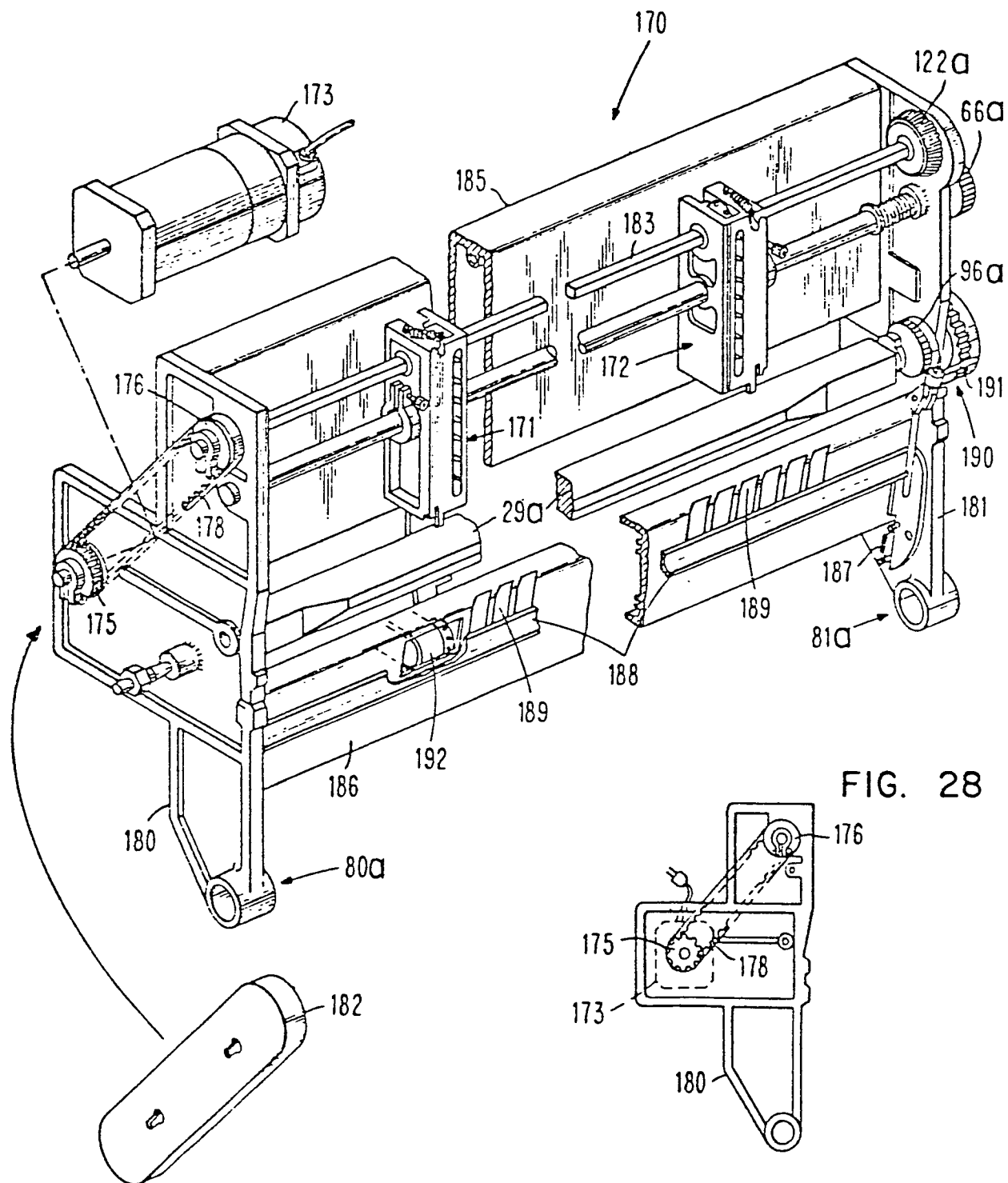
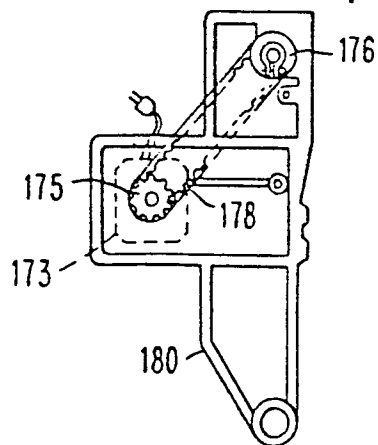


FIG. 28



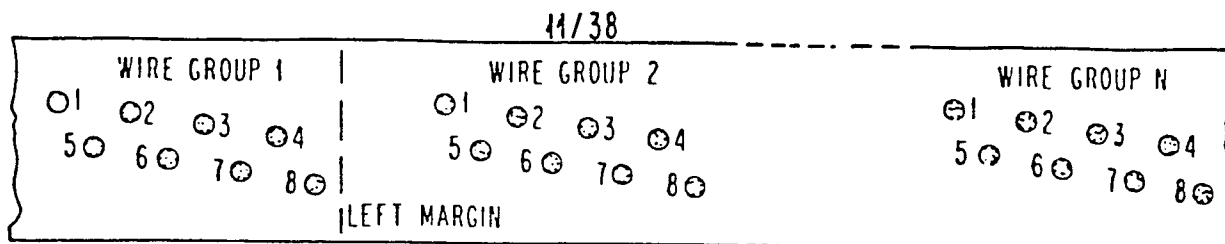
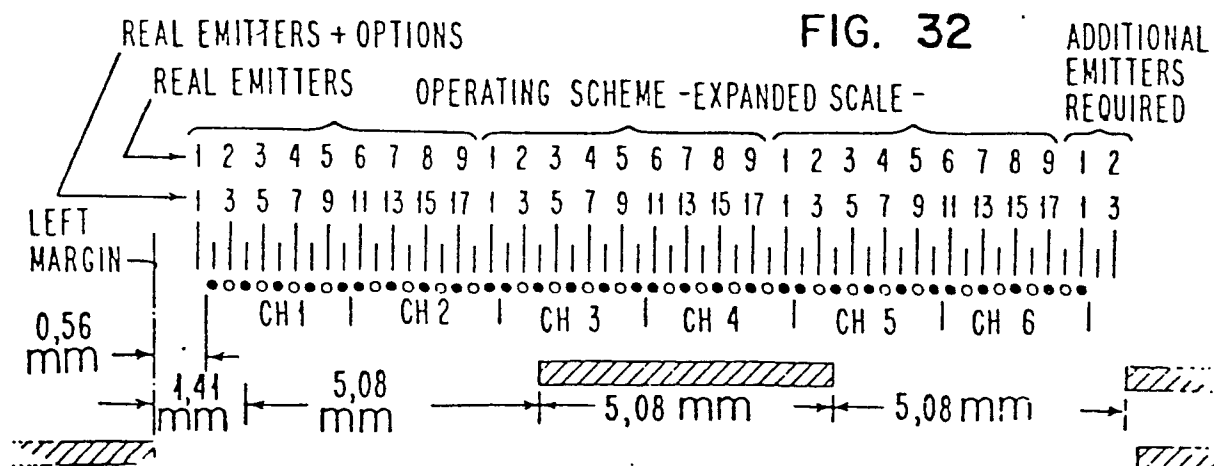
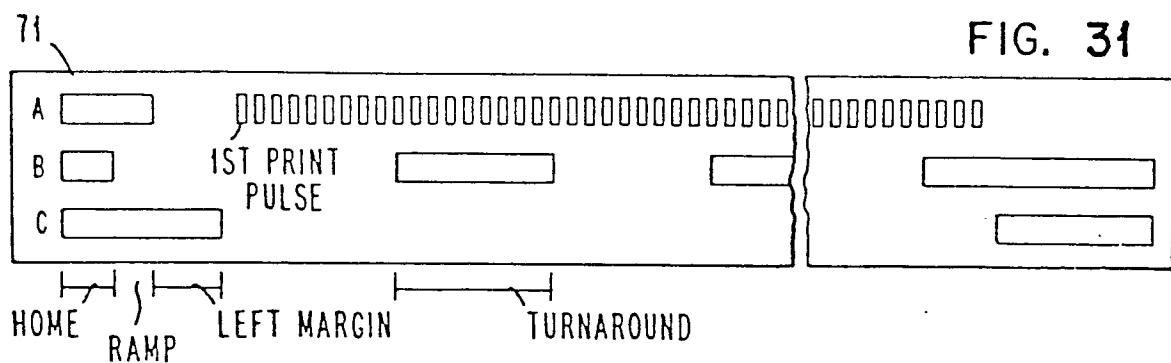
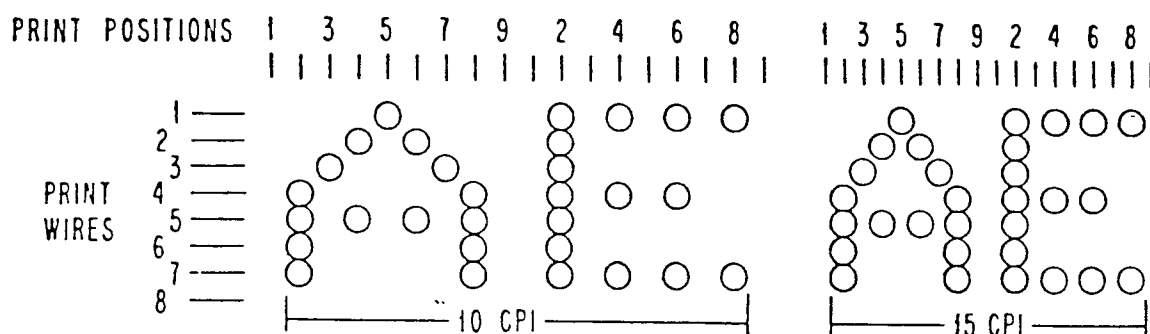


FIG. 29

FIG. 30



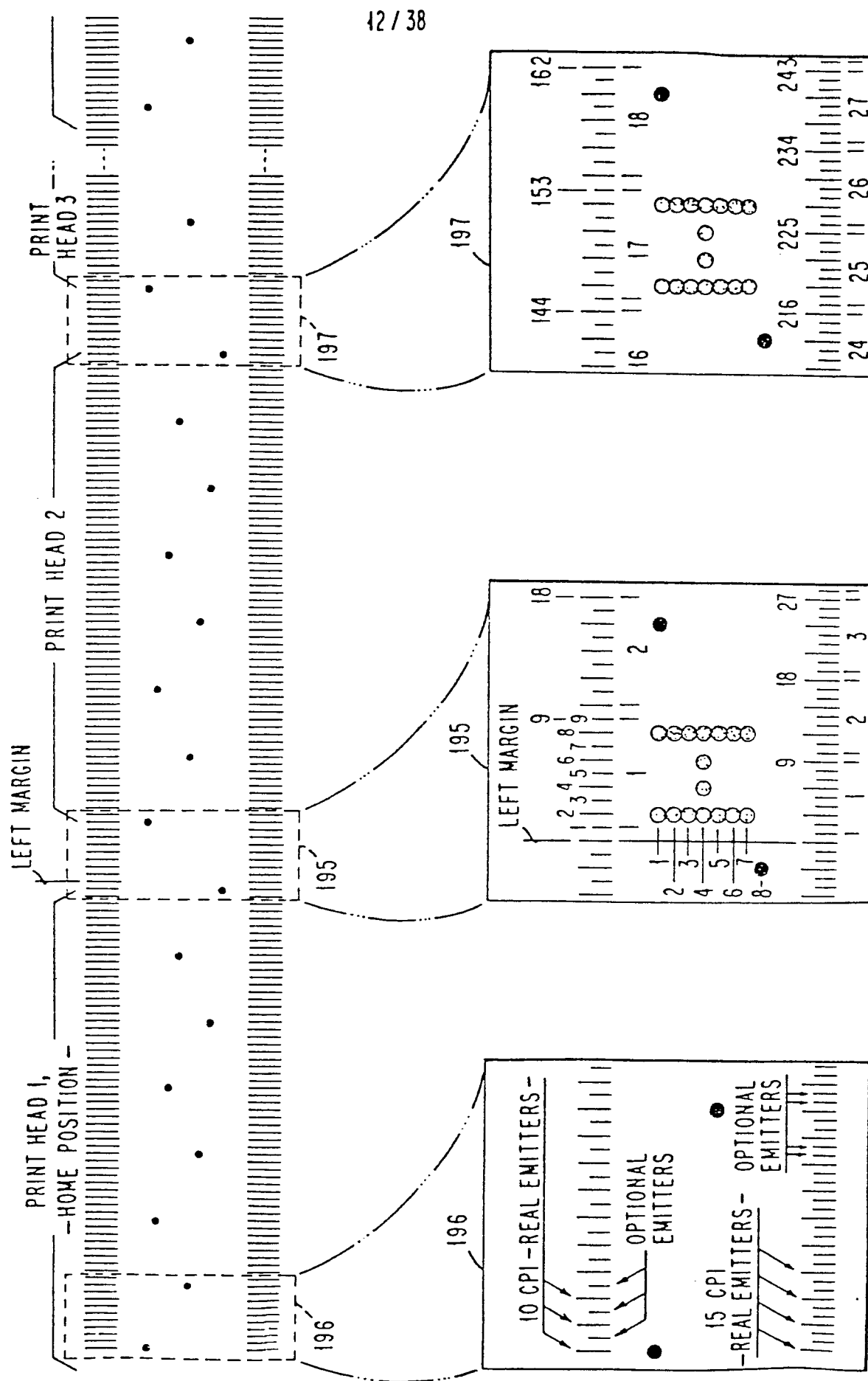


FIG. 33A

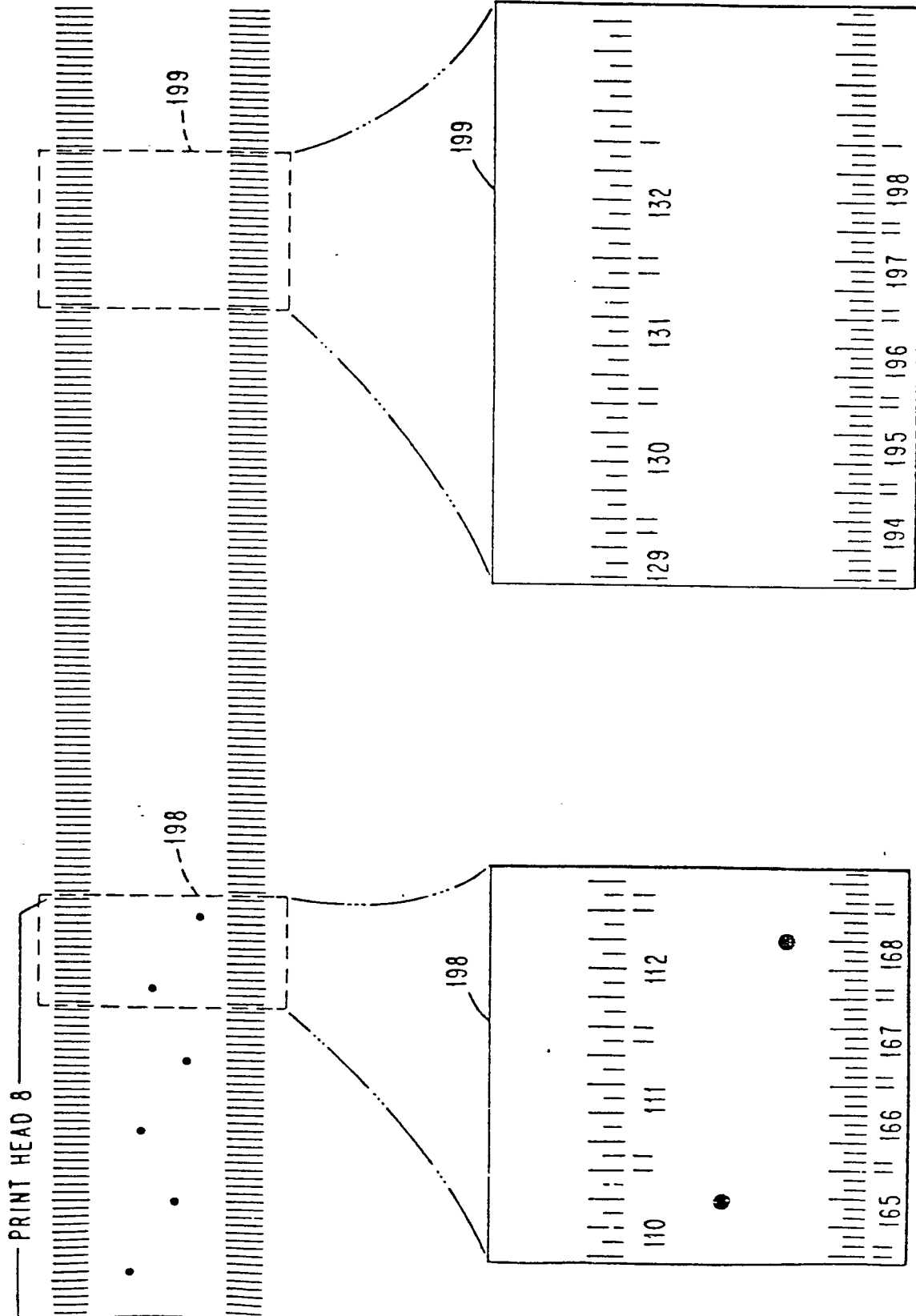


FIG. 33B

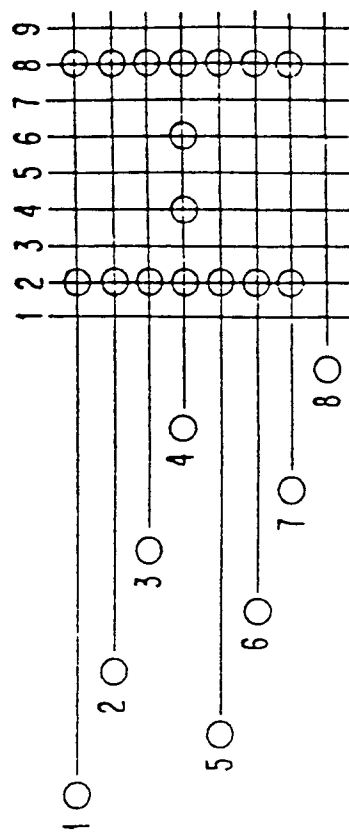


FIG. 36

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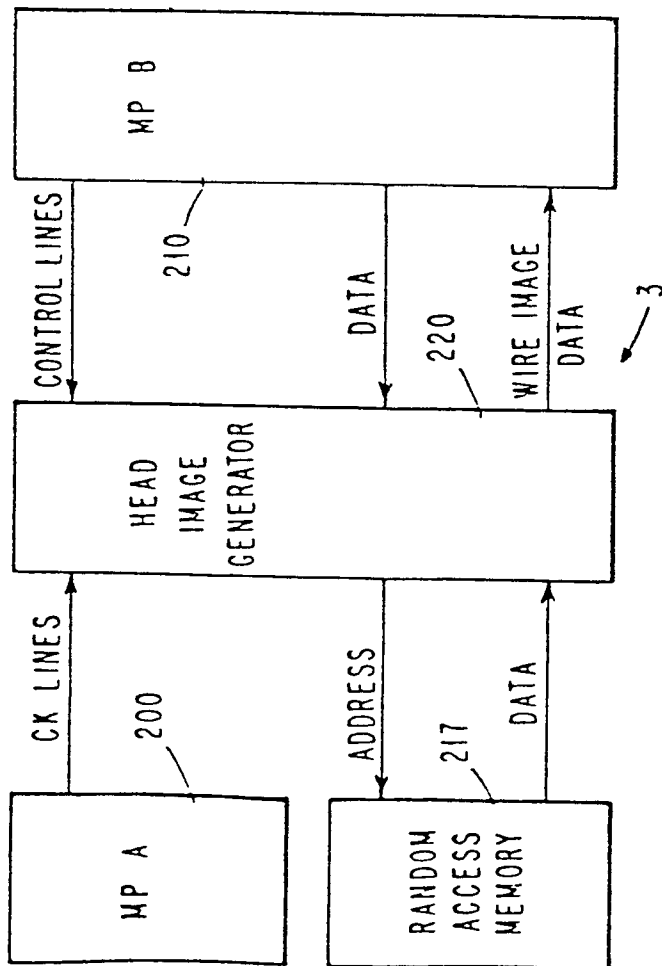
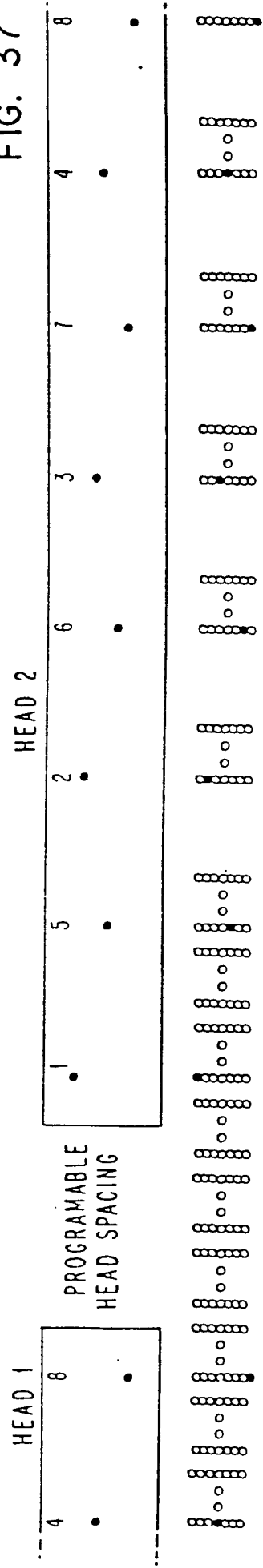


FIG. 35

FIG. 37



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FIG. 38

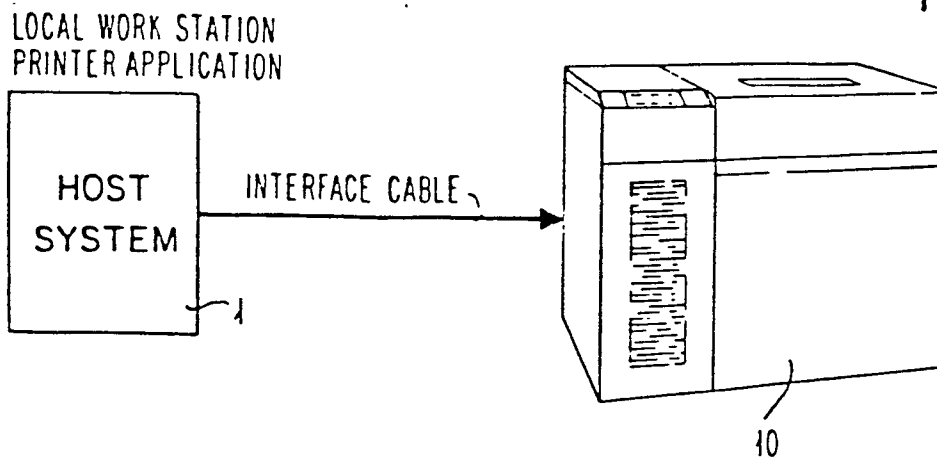


FIG. 39

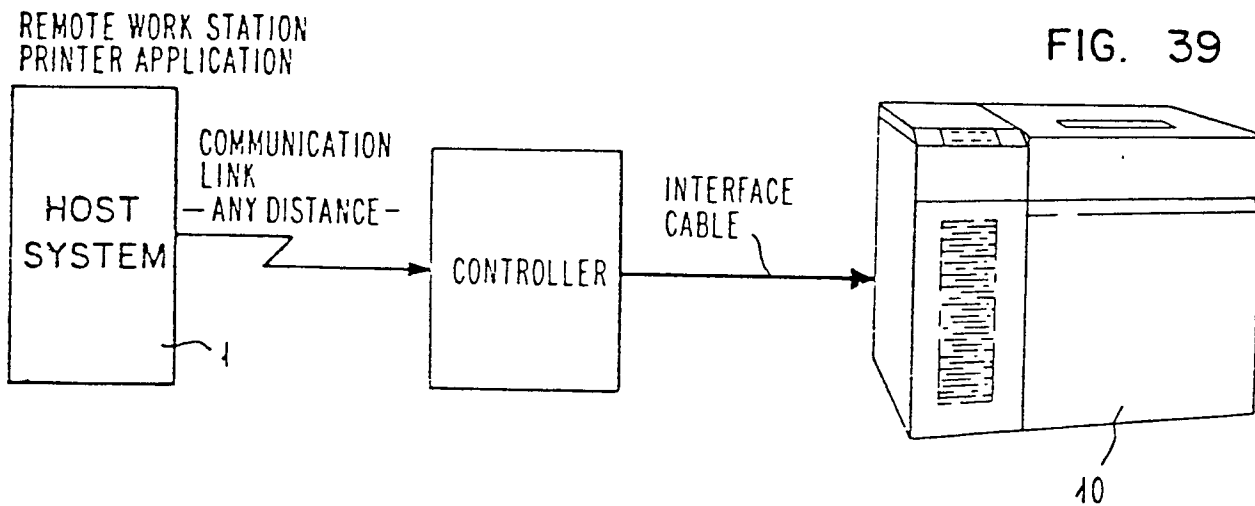
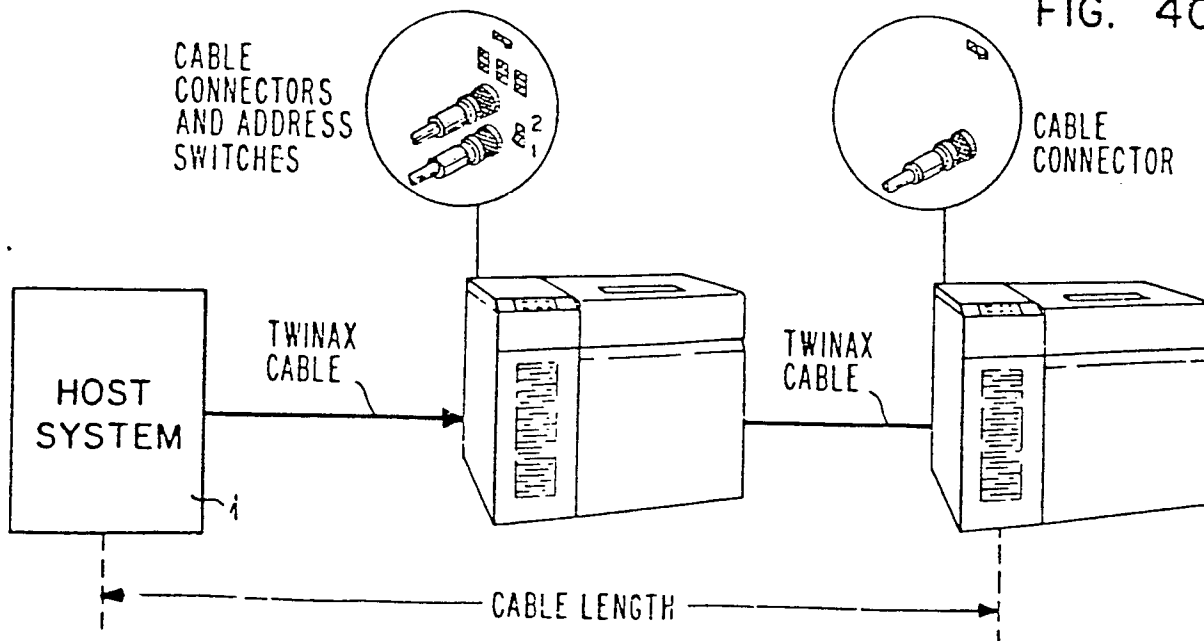
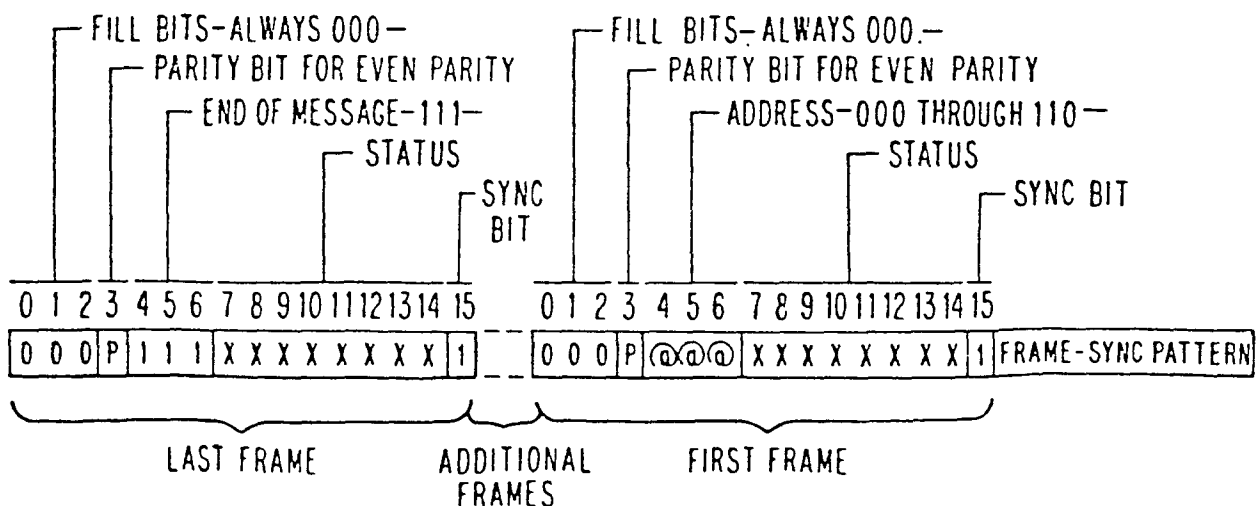
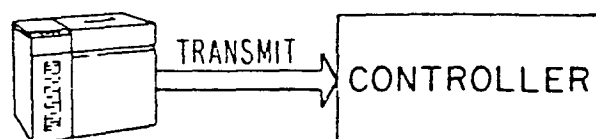
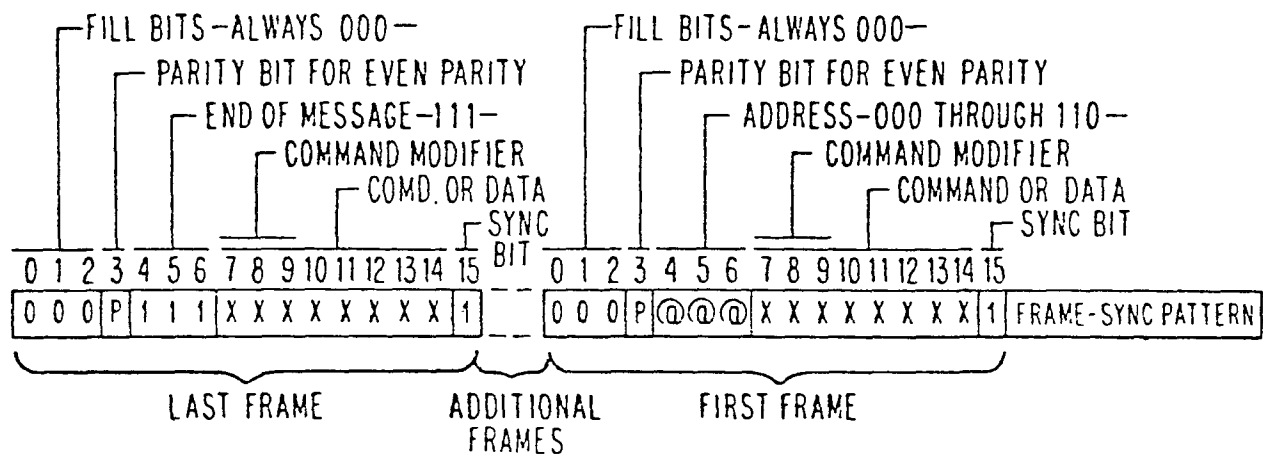
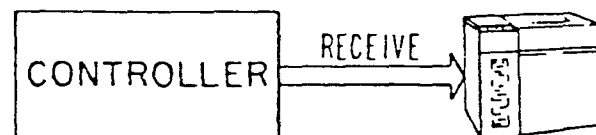
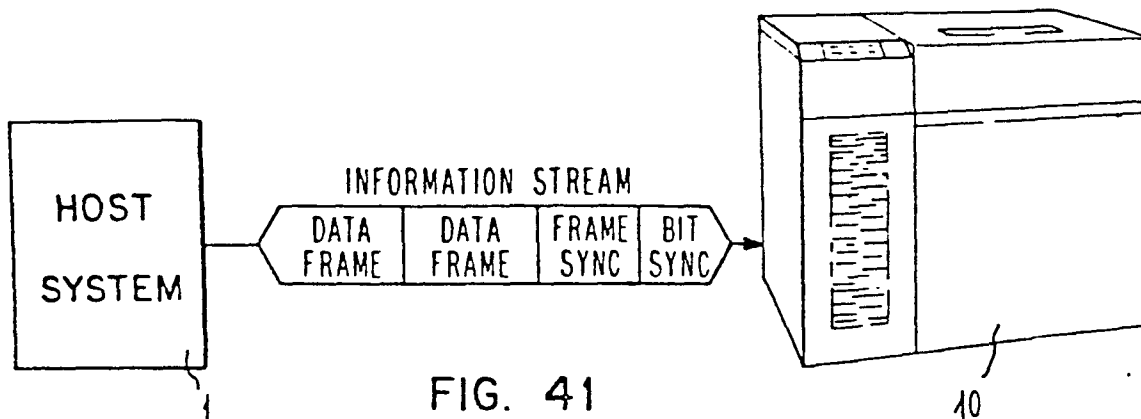


FIG. 40



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ADDRESSING HIGHLIGHTS

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FOR A SINGLE PRINTER, ADDRESS IS 000

WITH CABLE CONNECTOR FEATURE, USABLE ADDRESSES ARE 000 TO 110

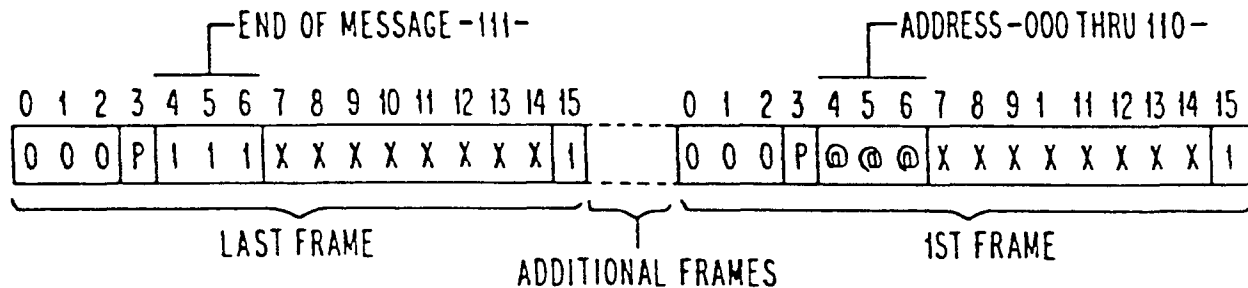
A BIT COMBINATION OF 111 INDICATES END-OF-MESSAGE & TERMINATES A
TRANSFER SEQUENCE

FIG. 44

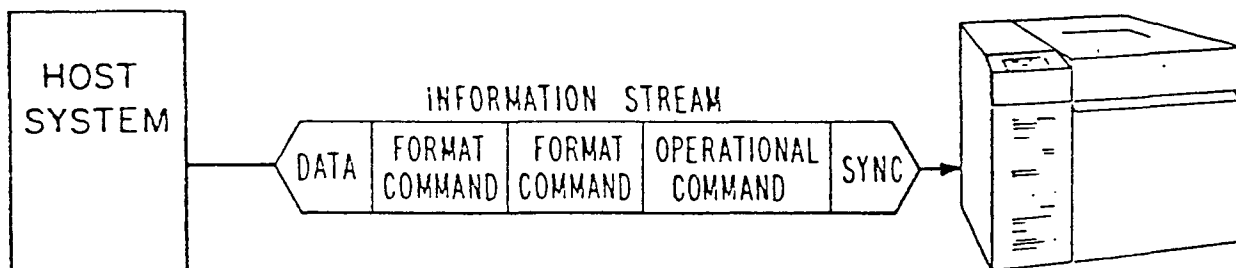
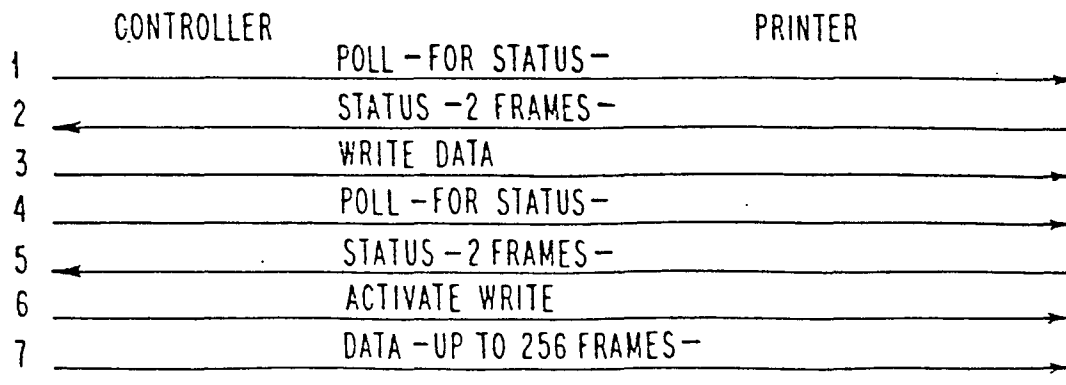


FIG. 45

SAMPLE TRANSFER SEQUENCE FOR PRINTING DATA

- 1, 4: POLL COMMAND REQUESTS PRINTER STATUS
 2, 5: RESPONSE STATUS FRAMES INFORM CONTROLLER OF PRINTER AVAILABILITY
 3: WRITE DATA COMMAND PREPARES PRINTER FOR PRINTING OPERATION
 6: ACTIVATE WRITE COMMAND STARTS PRINTING OPERATION
 7: CONTROLLER SENDS DATA & EMBEDDED FORMATTING COMMANDS TO PRINTER

FIG. 46

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OPERATIONAL COMMAND

POLL-X0-

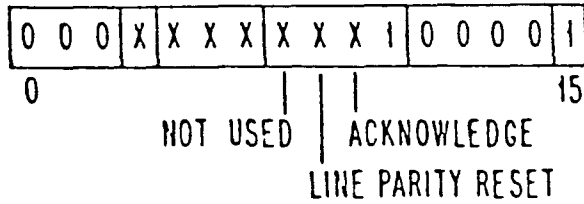


FIG. 47A

FORMATTING COMMAND

NEW LINE-15-

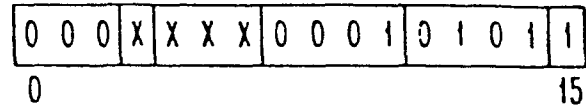


FIG. 47B

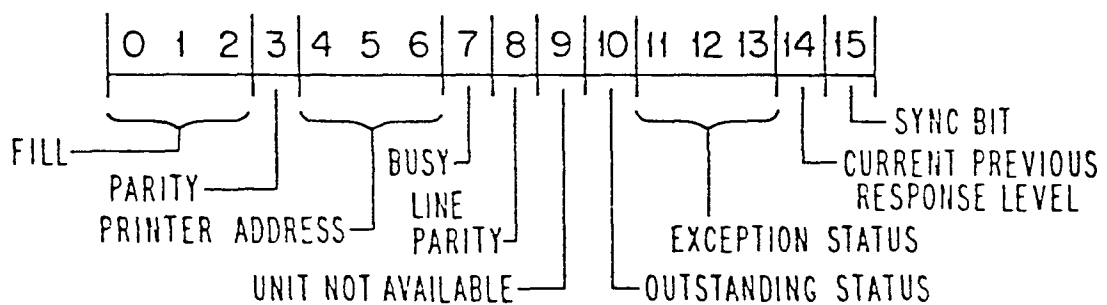
POLL STATUS FRAME 1

FIG. 48

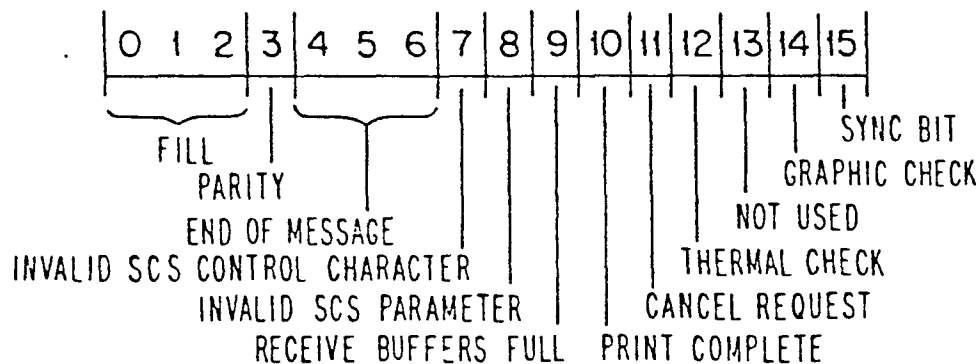
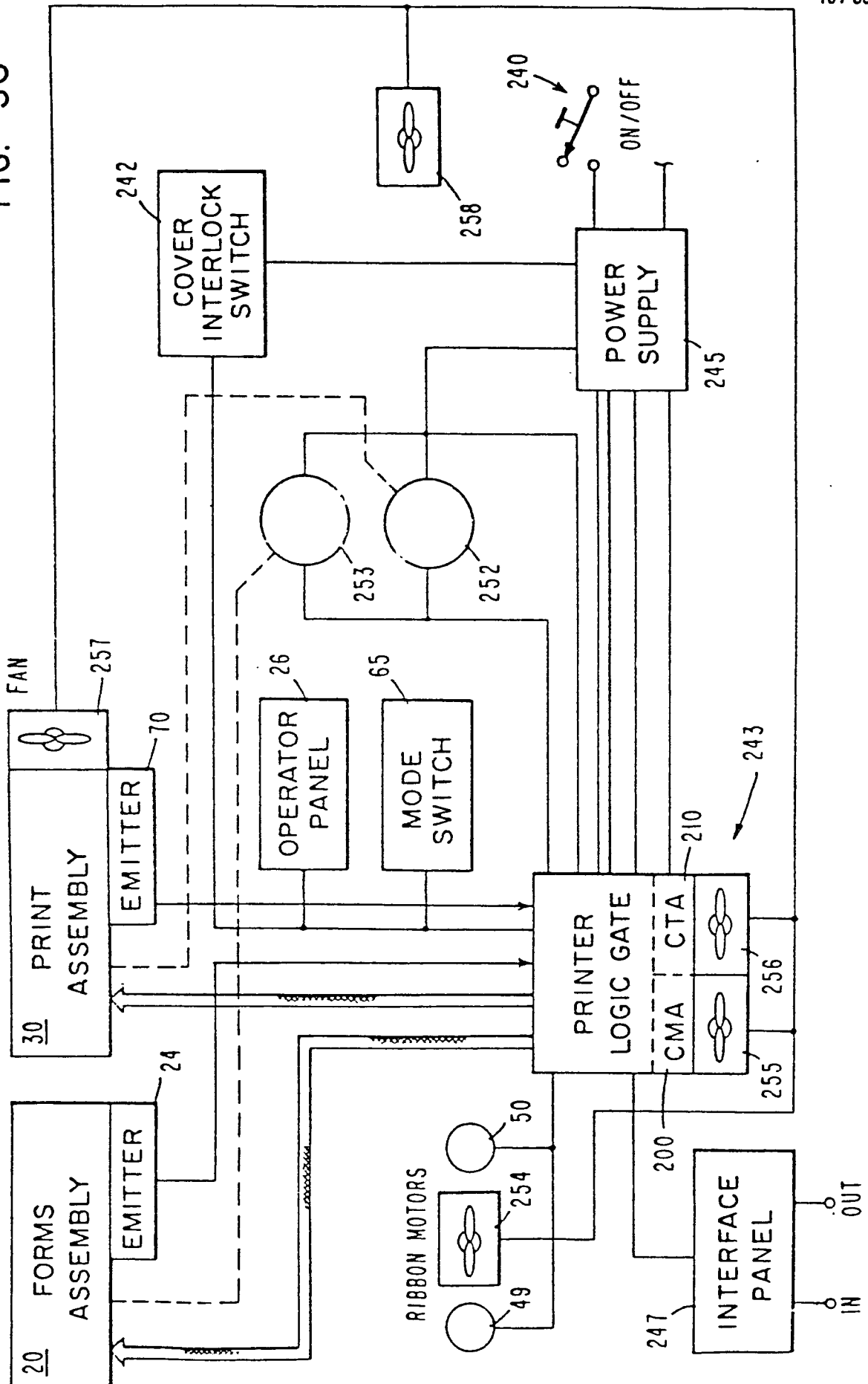
POLL STATUS FRAME 2

FIG. 49

FIG. 50



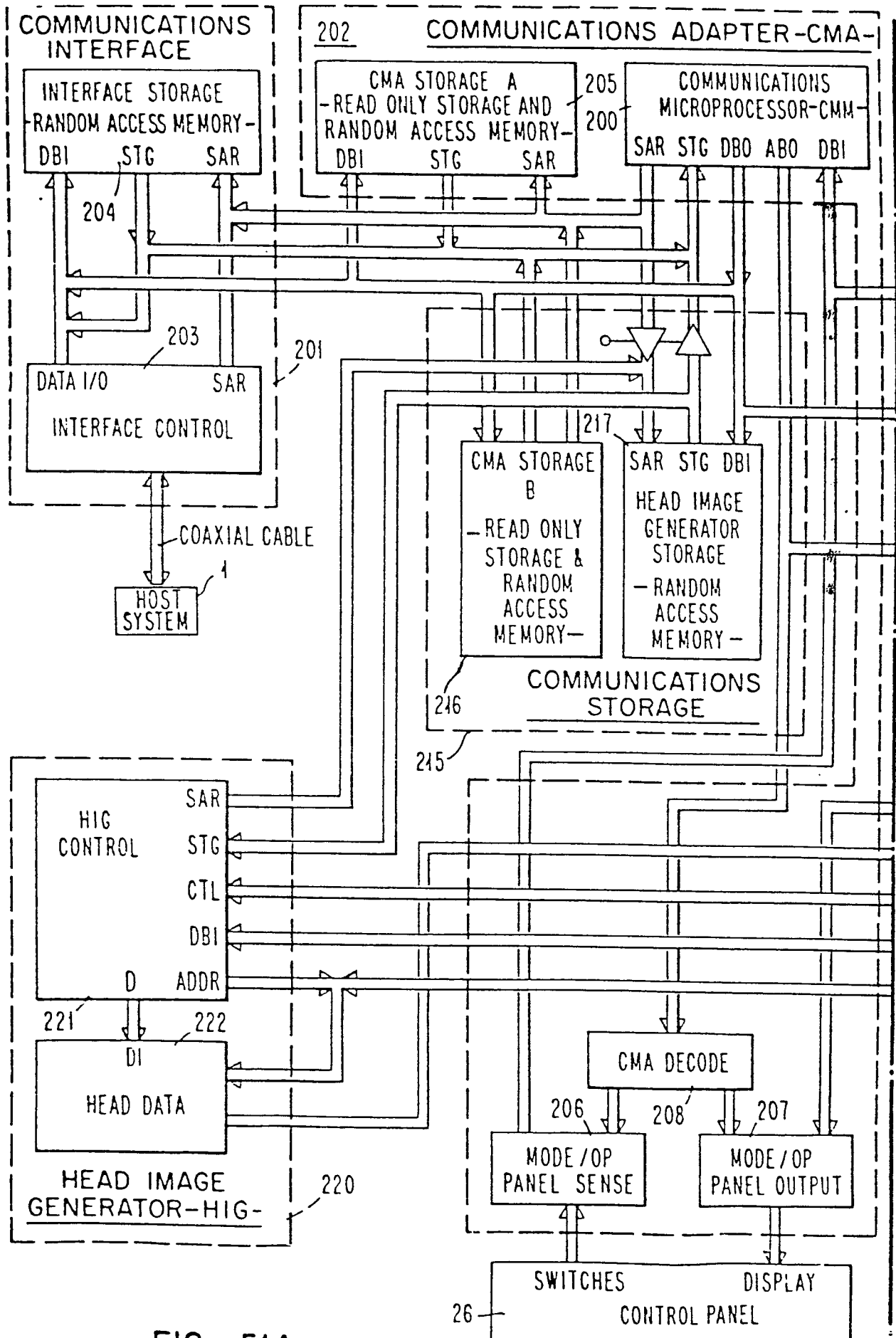
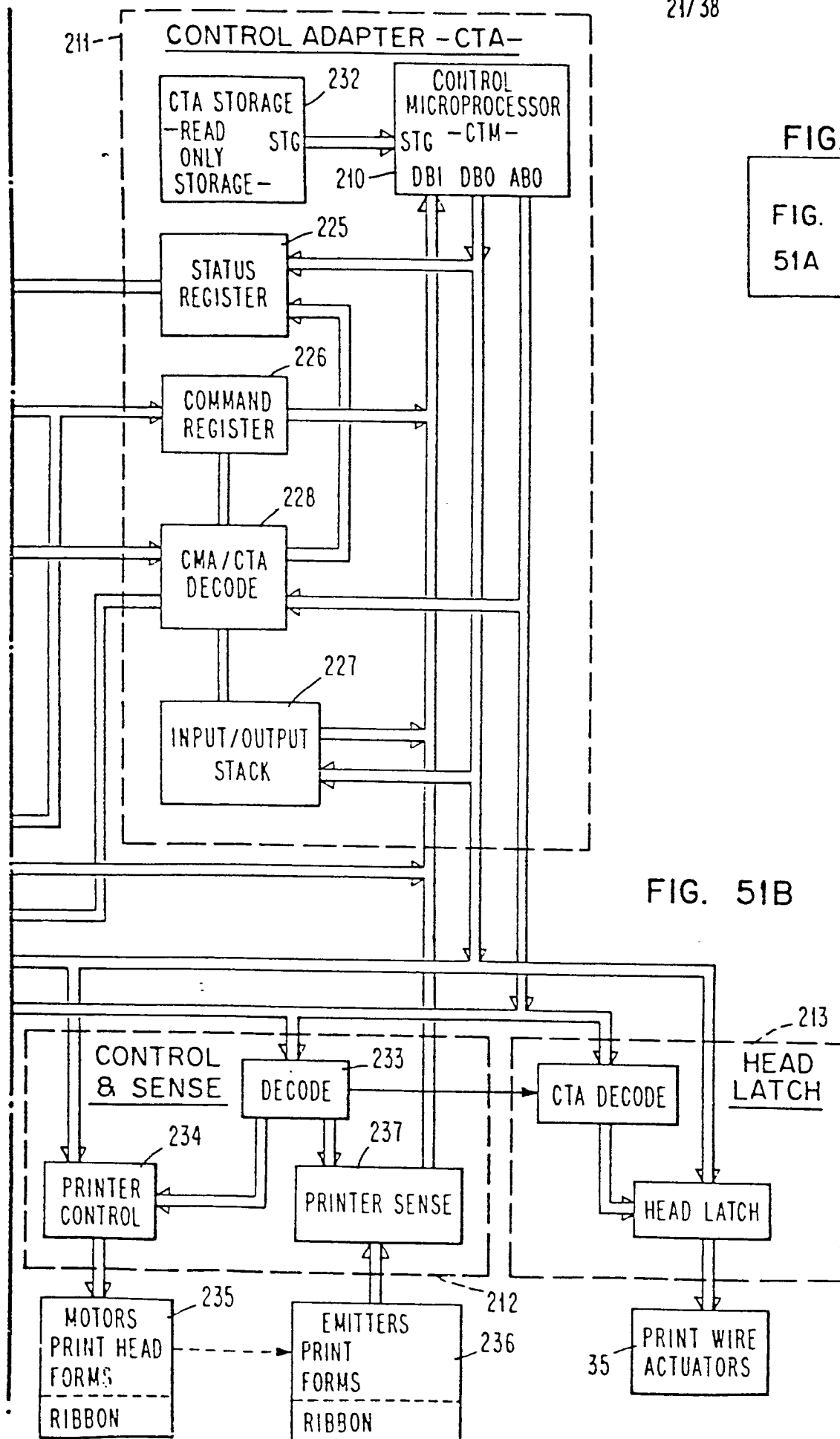


FIG. 51A

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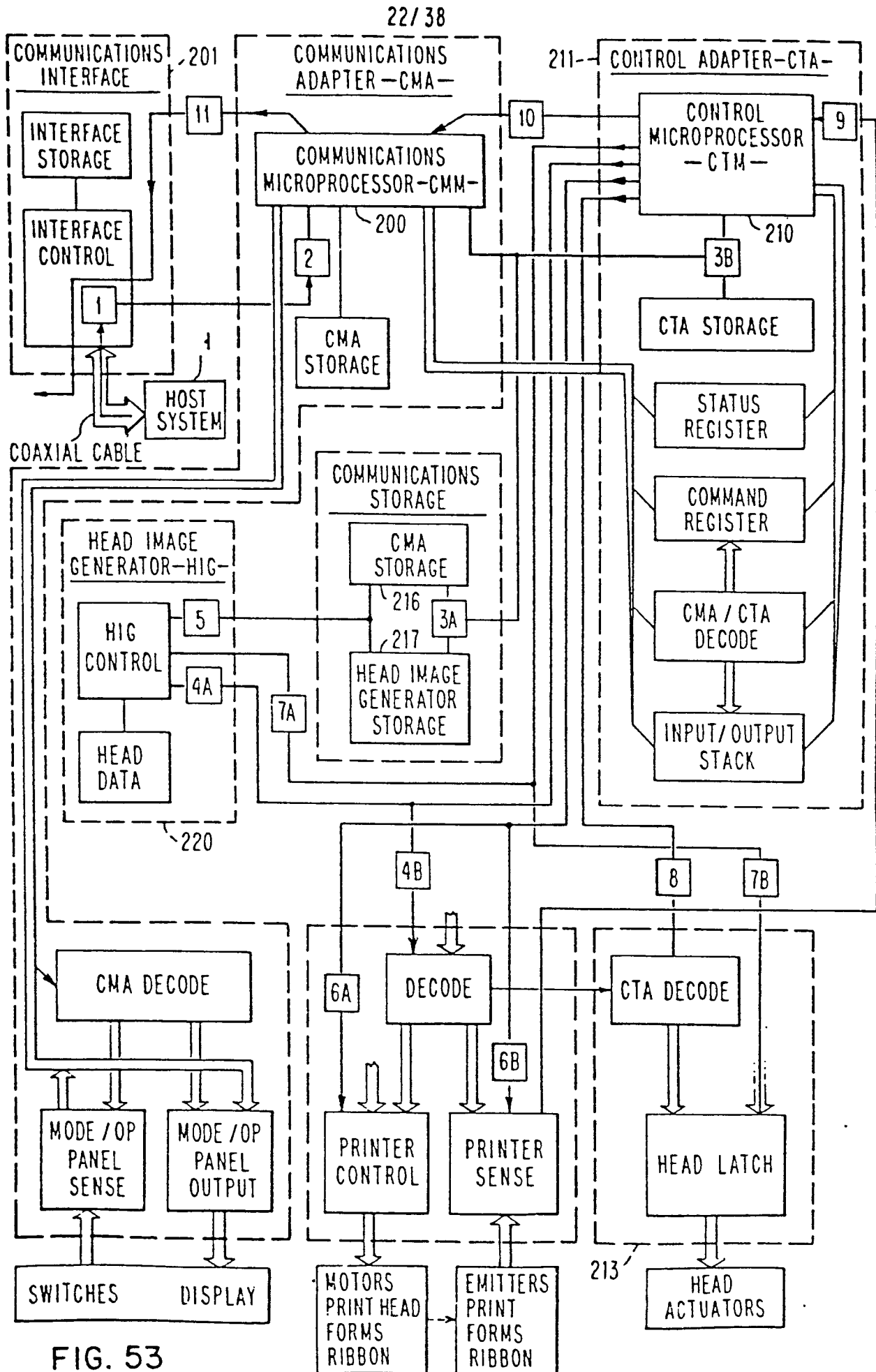
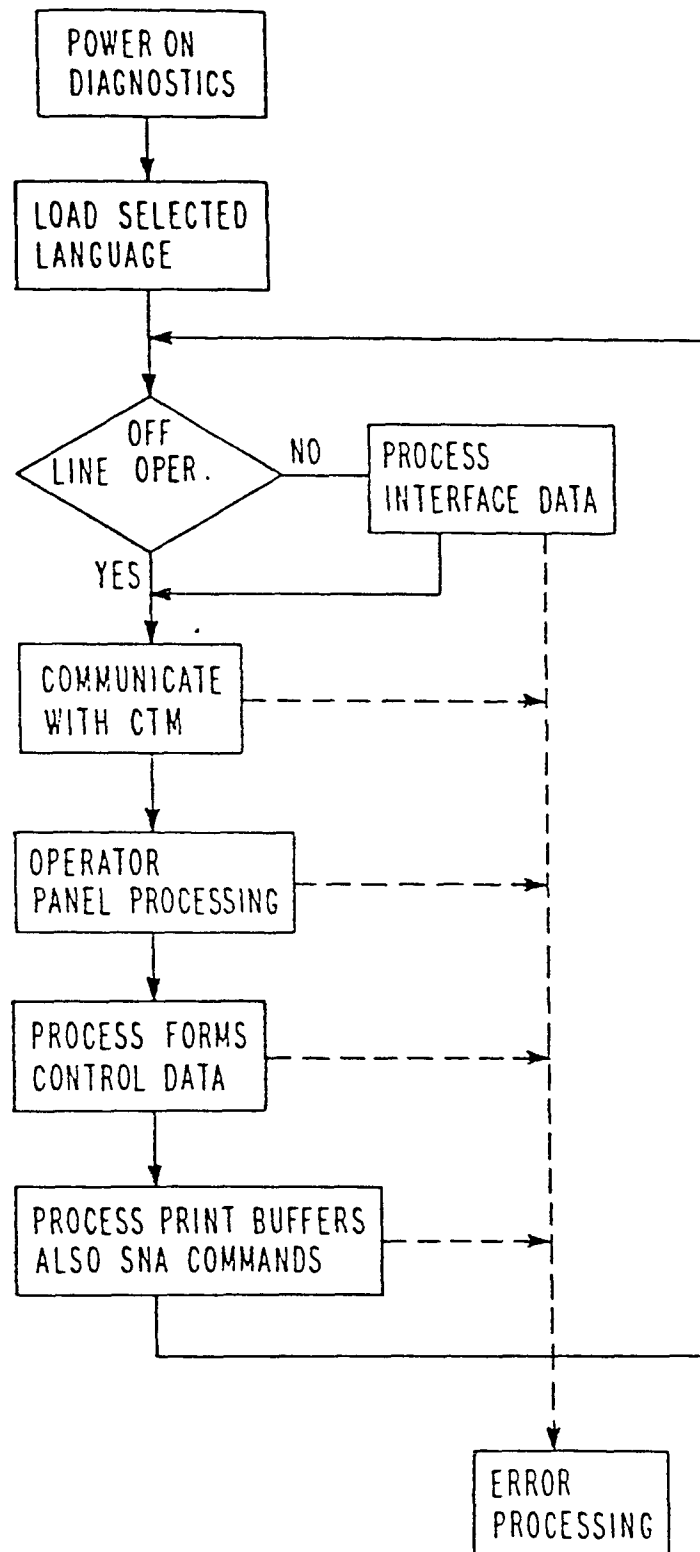


FIG. 54



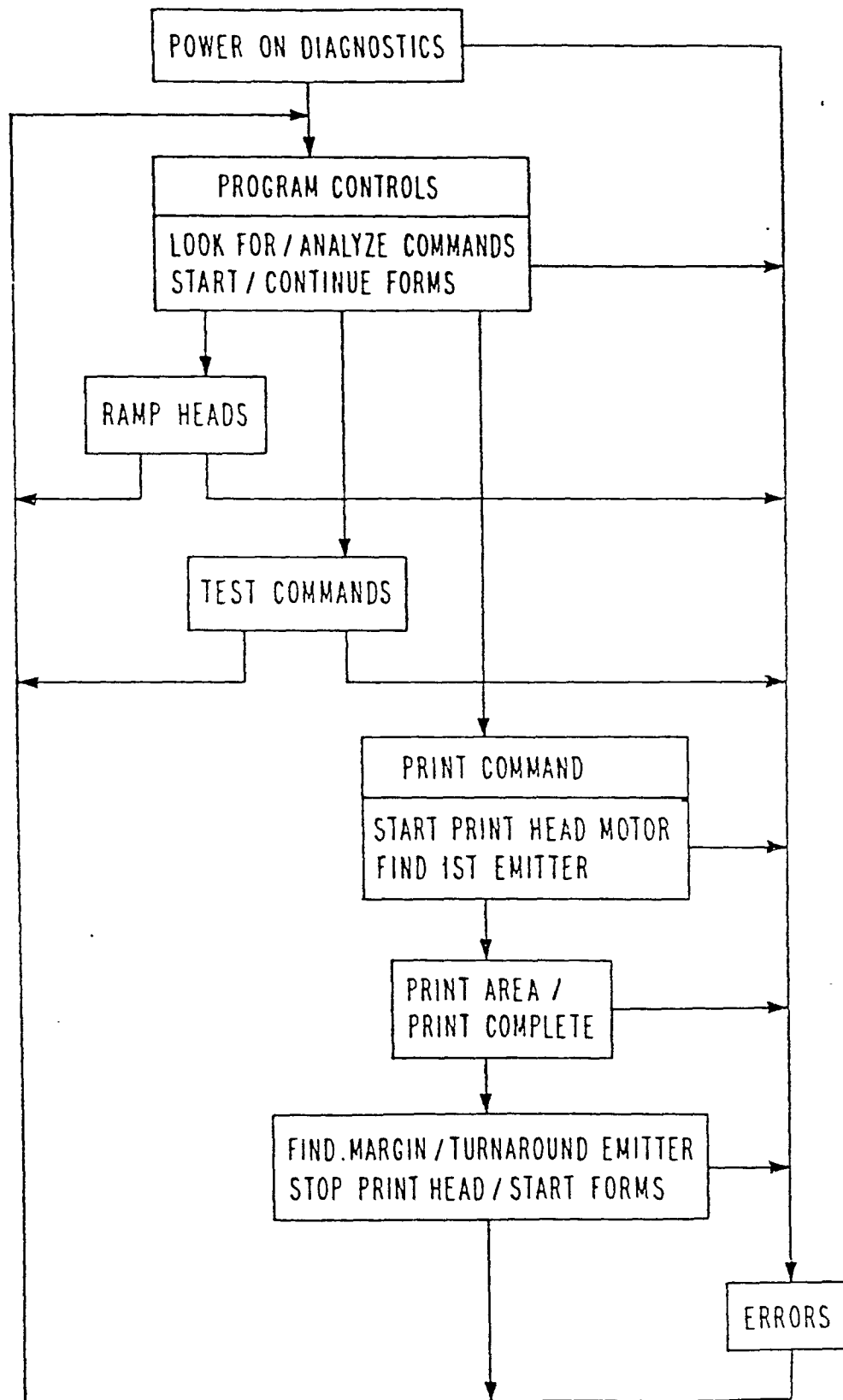
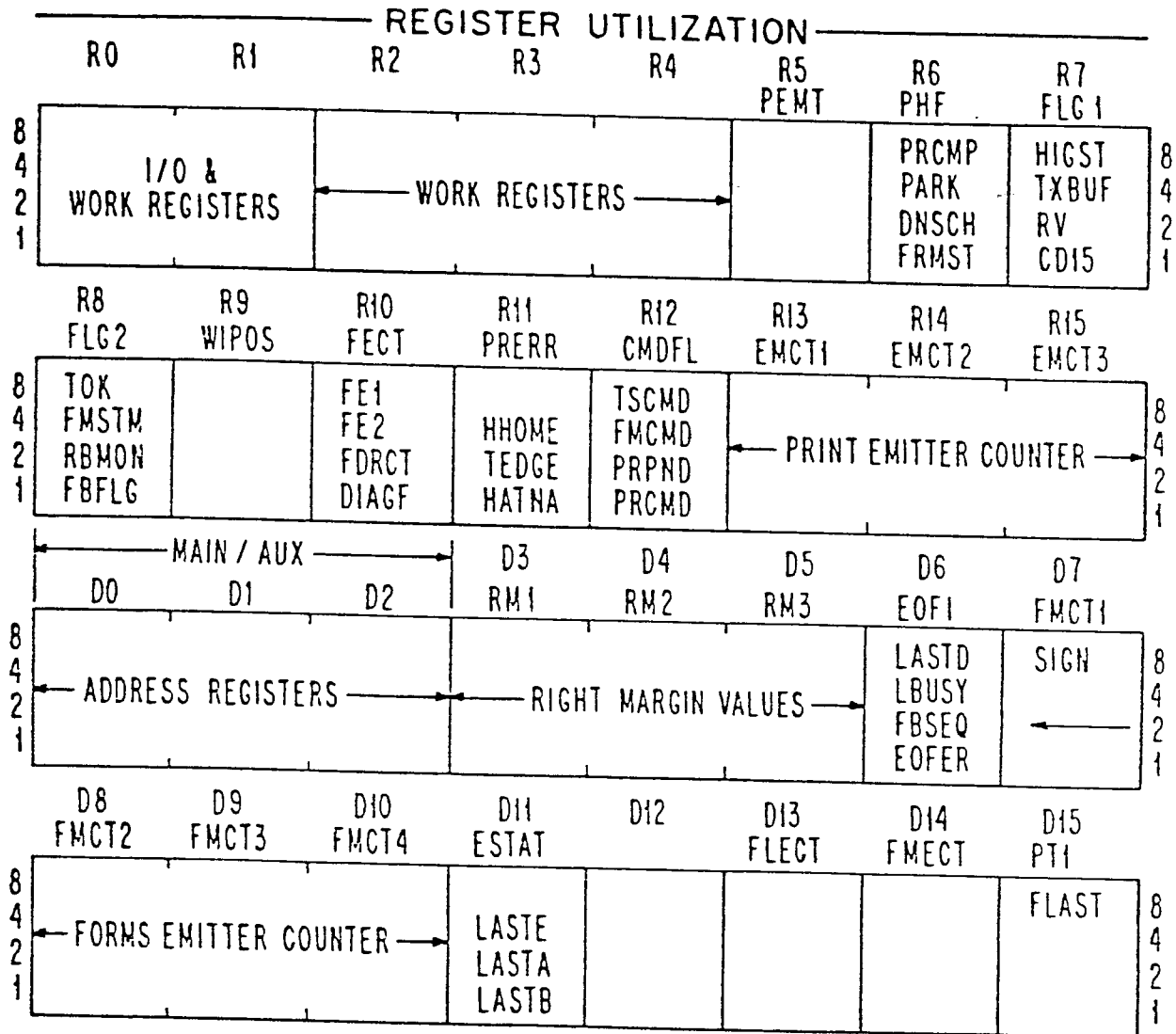


FIG. 56



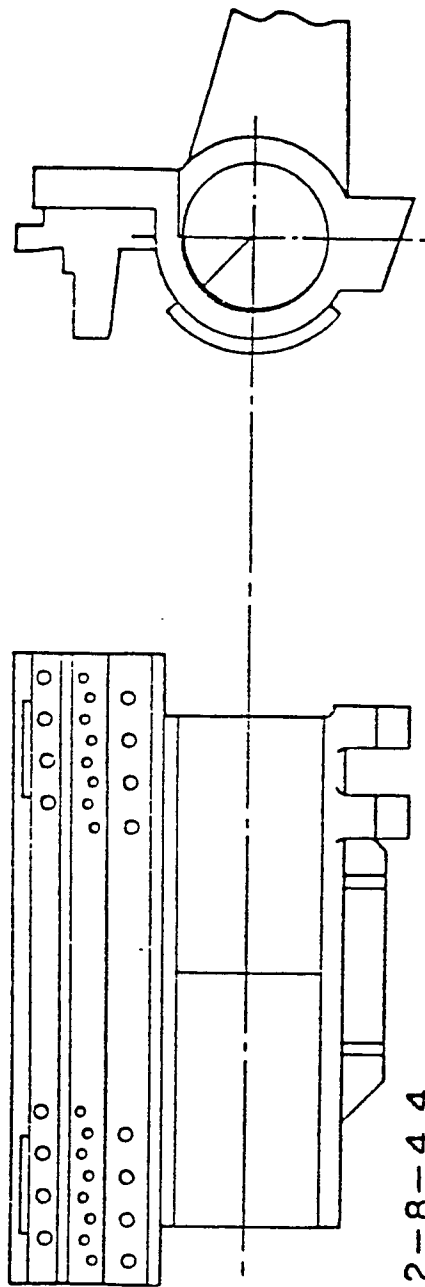


FIG. 57

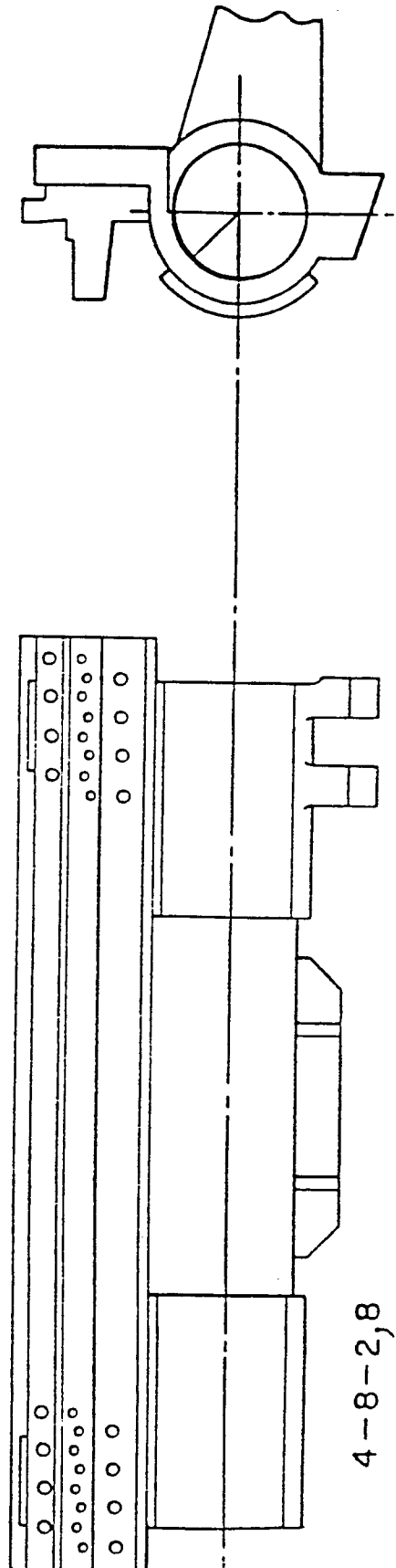


FIG. 58

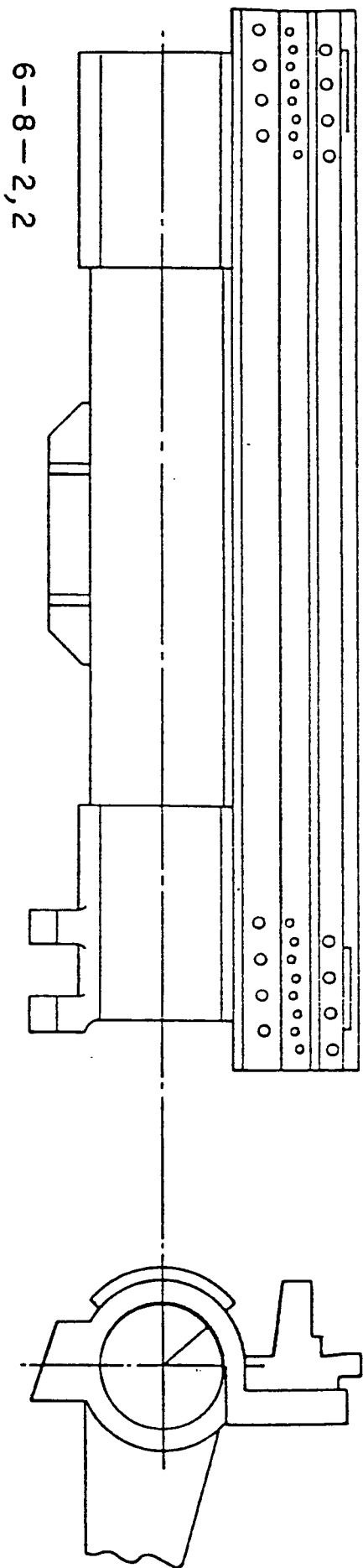


FIG. 59

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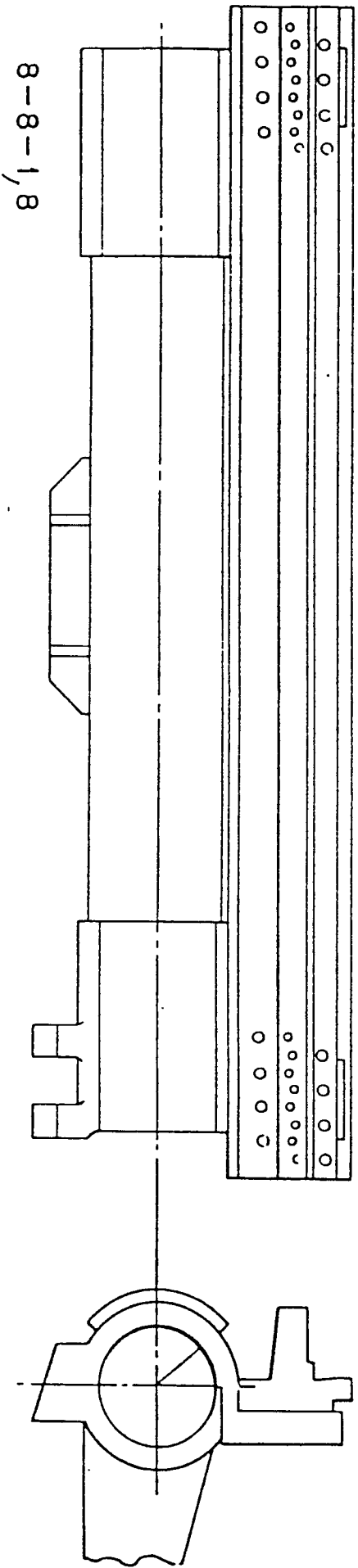


FIG. 60

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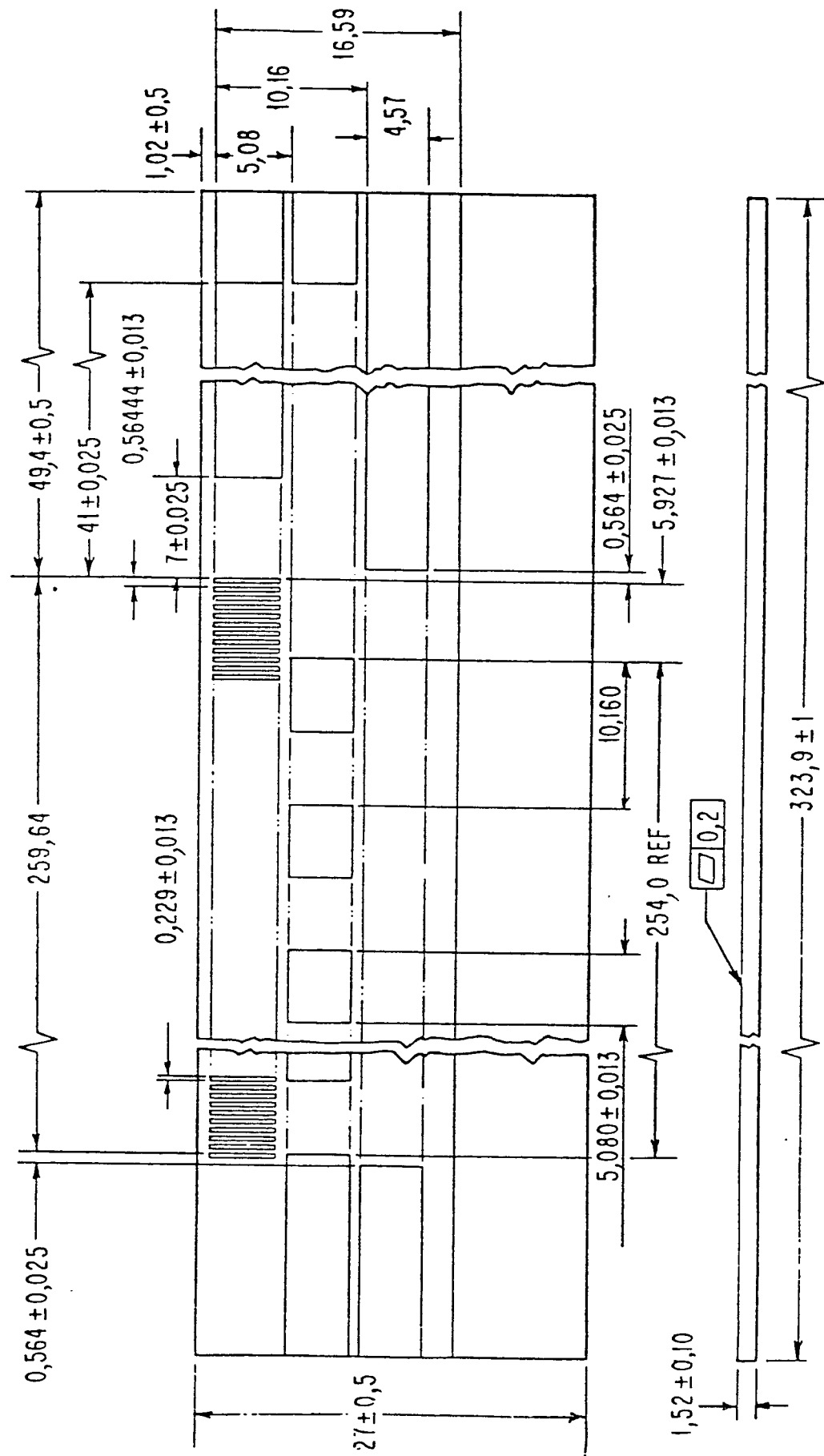


FIG. 61

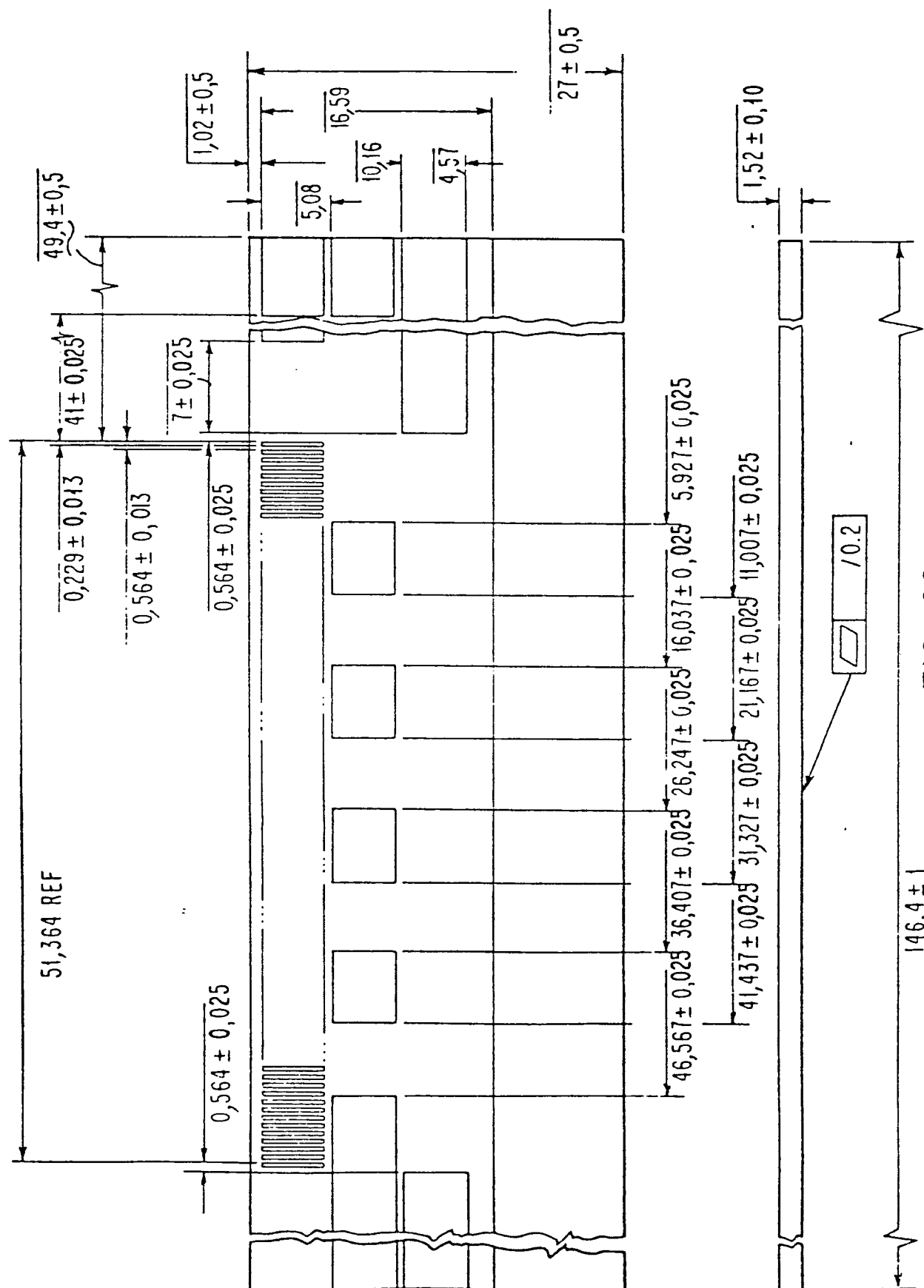


FIG. 62

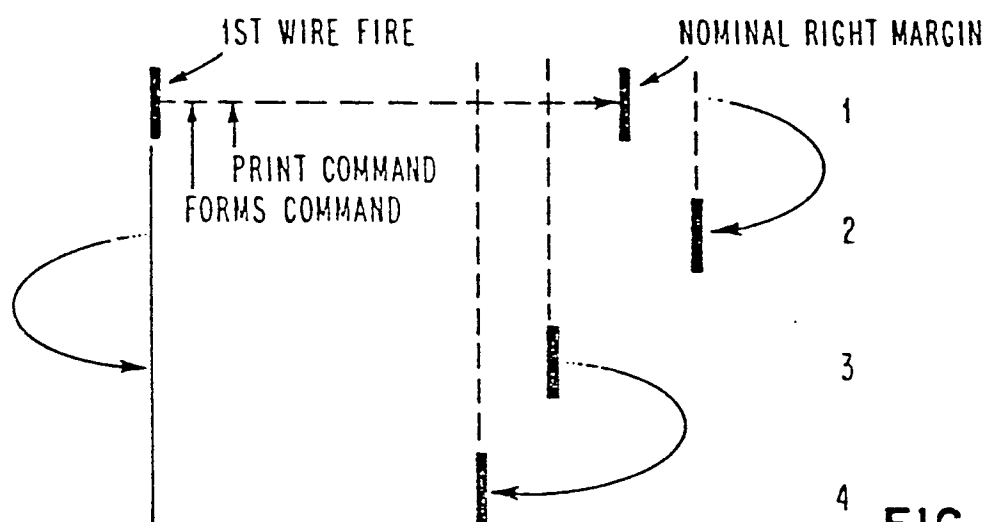


FIG. 63

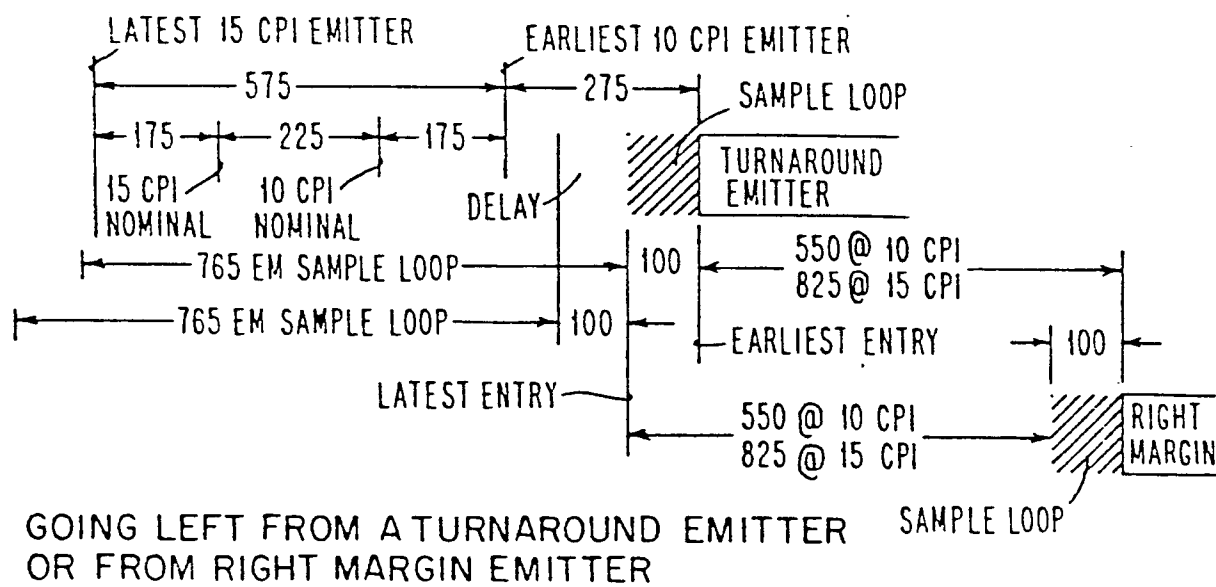


FIG. 64

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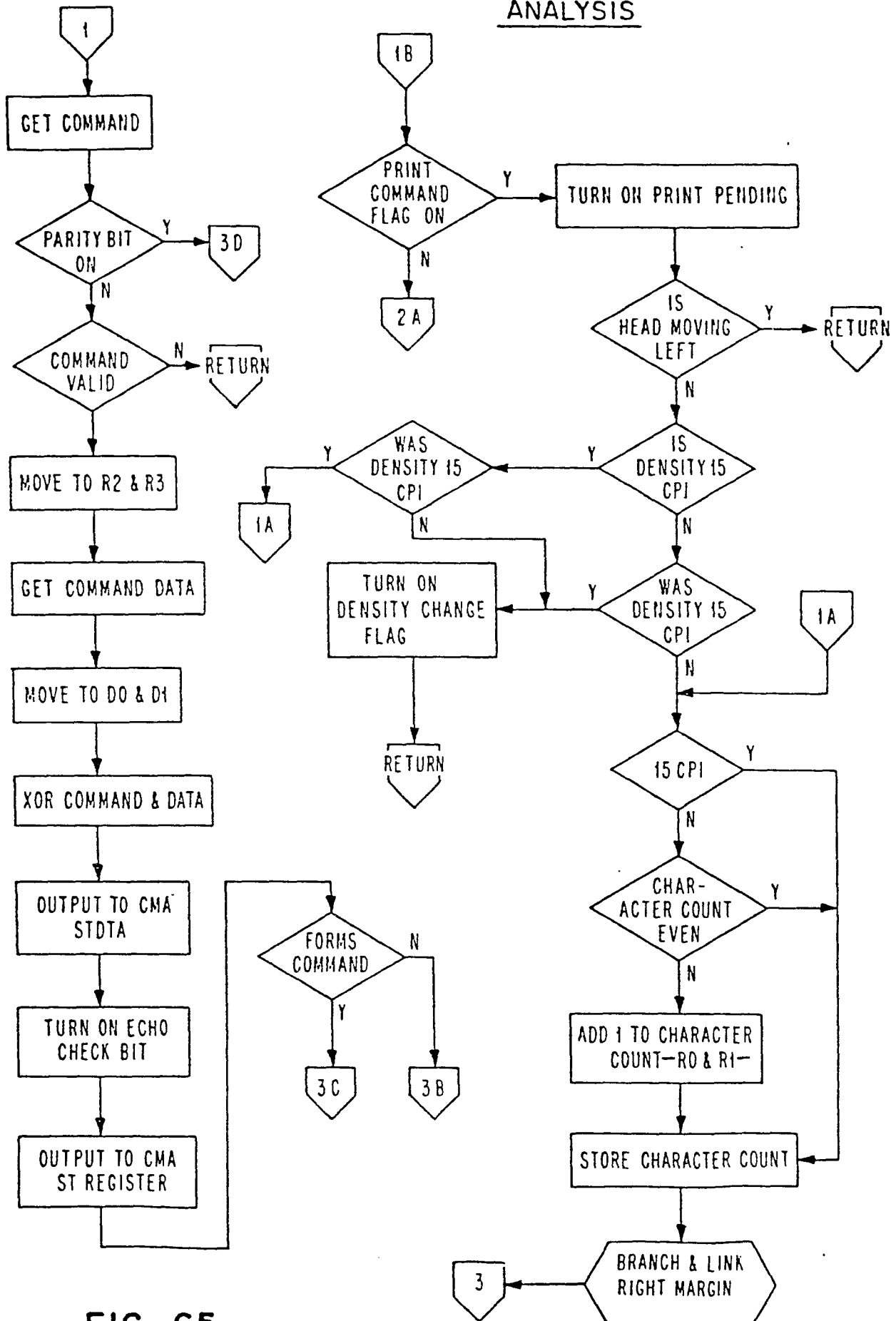
ANALYSIS

FIG. 65

ANALYSIS -CONTINUED-

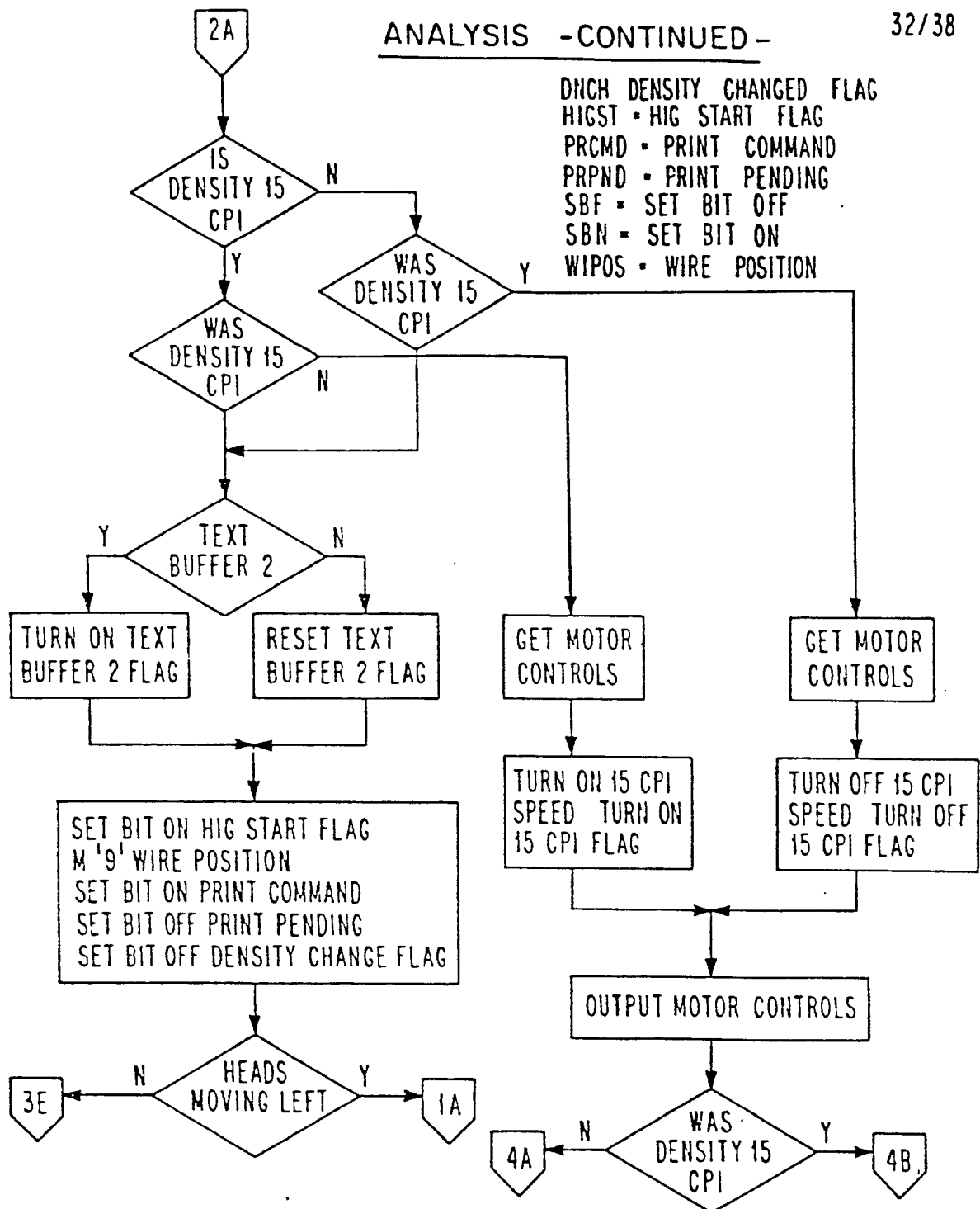


FIG. 66

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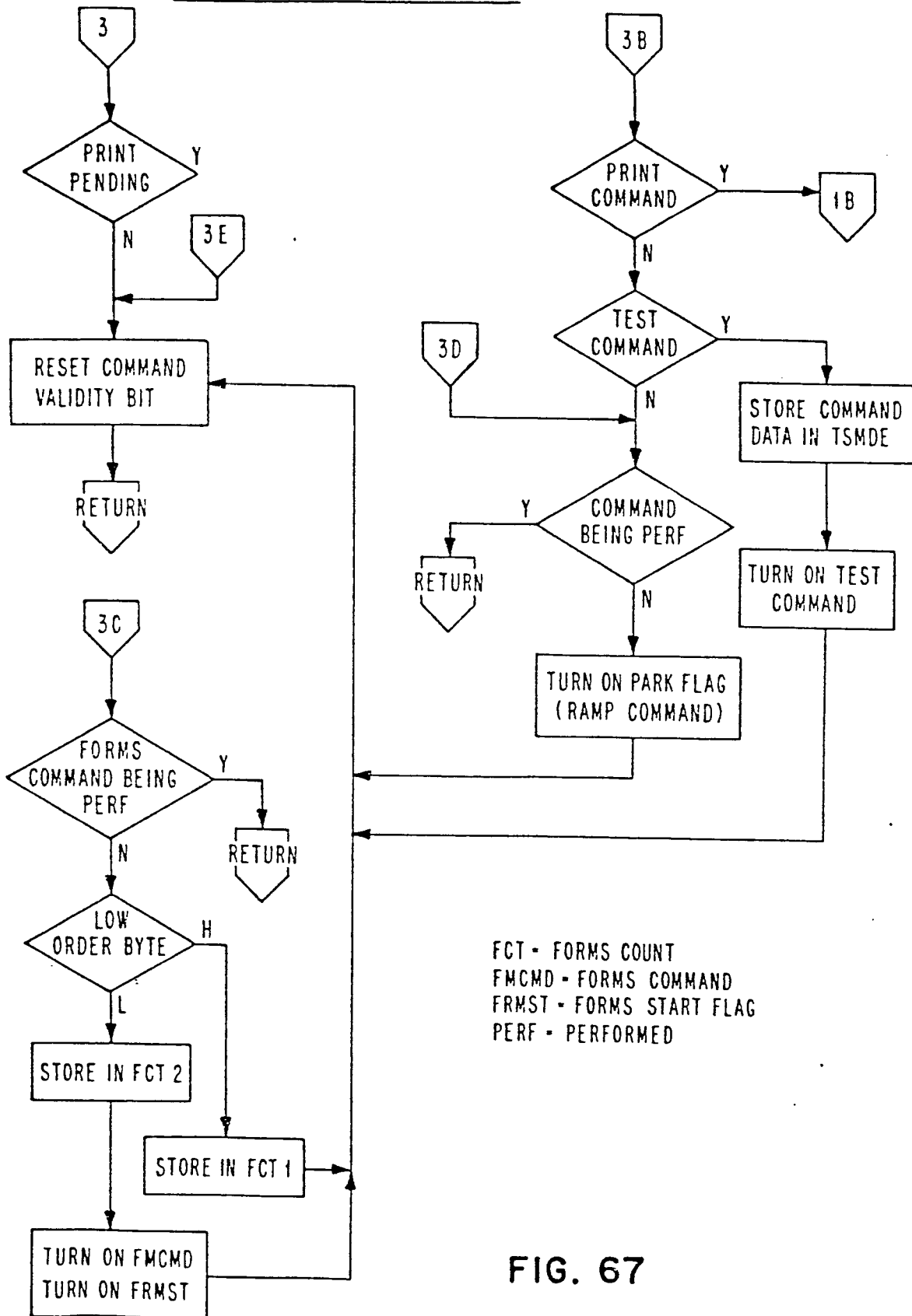
ANALYSIS - CONTINUED

FIG. 67

ANALYSIS - CONTINUED

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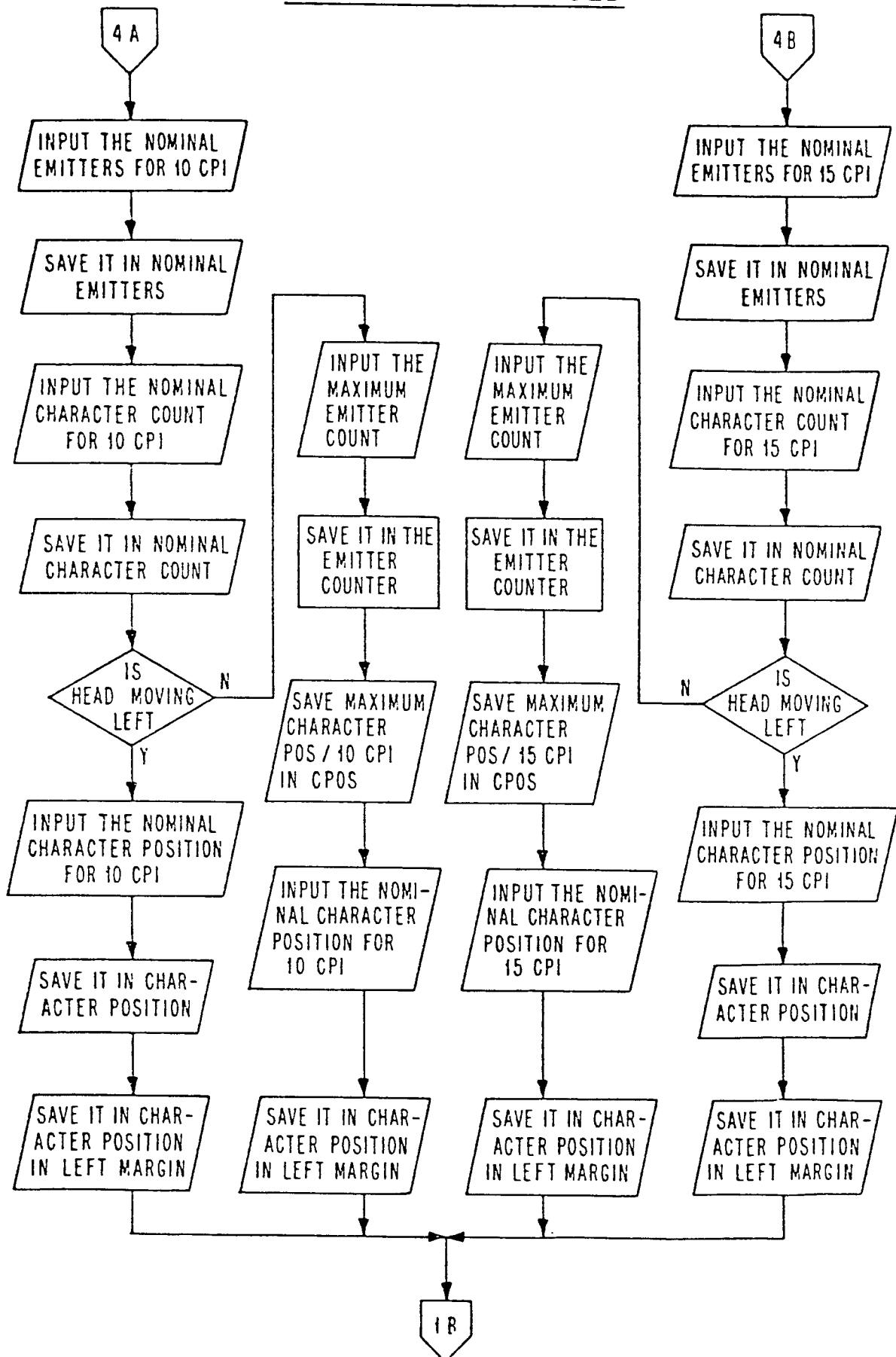


FIG. 68

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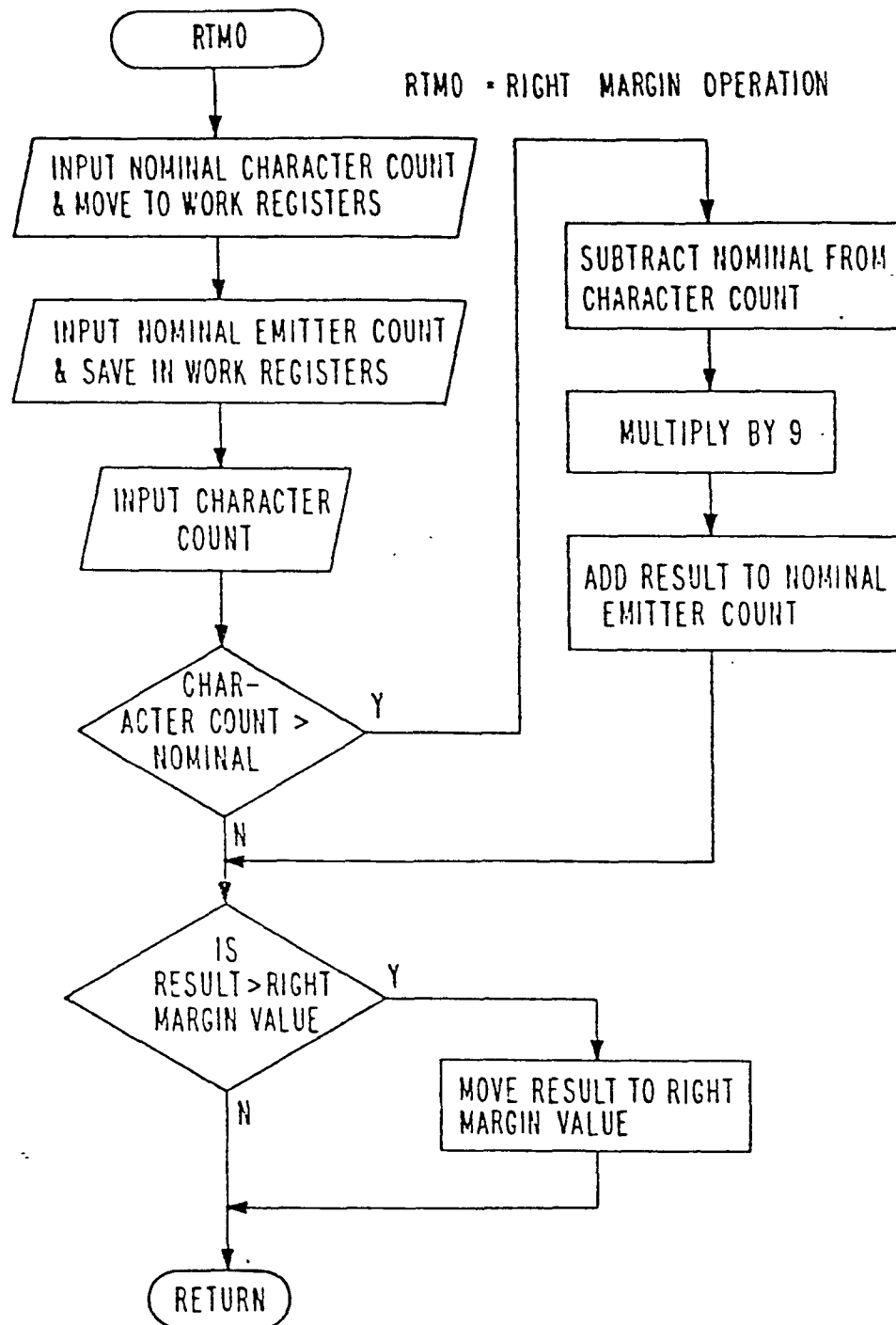


FIG. 69

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HEAD MOVING RIGHT IN PRINT AREA, PRINTING
COMPLETE.-ENTERED AT REAL EMITTER: 10 CPI CHARACTER COUNT EVEN-

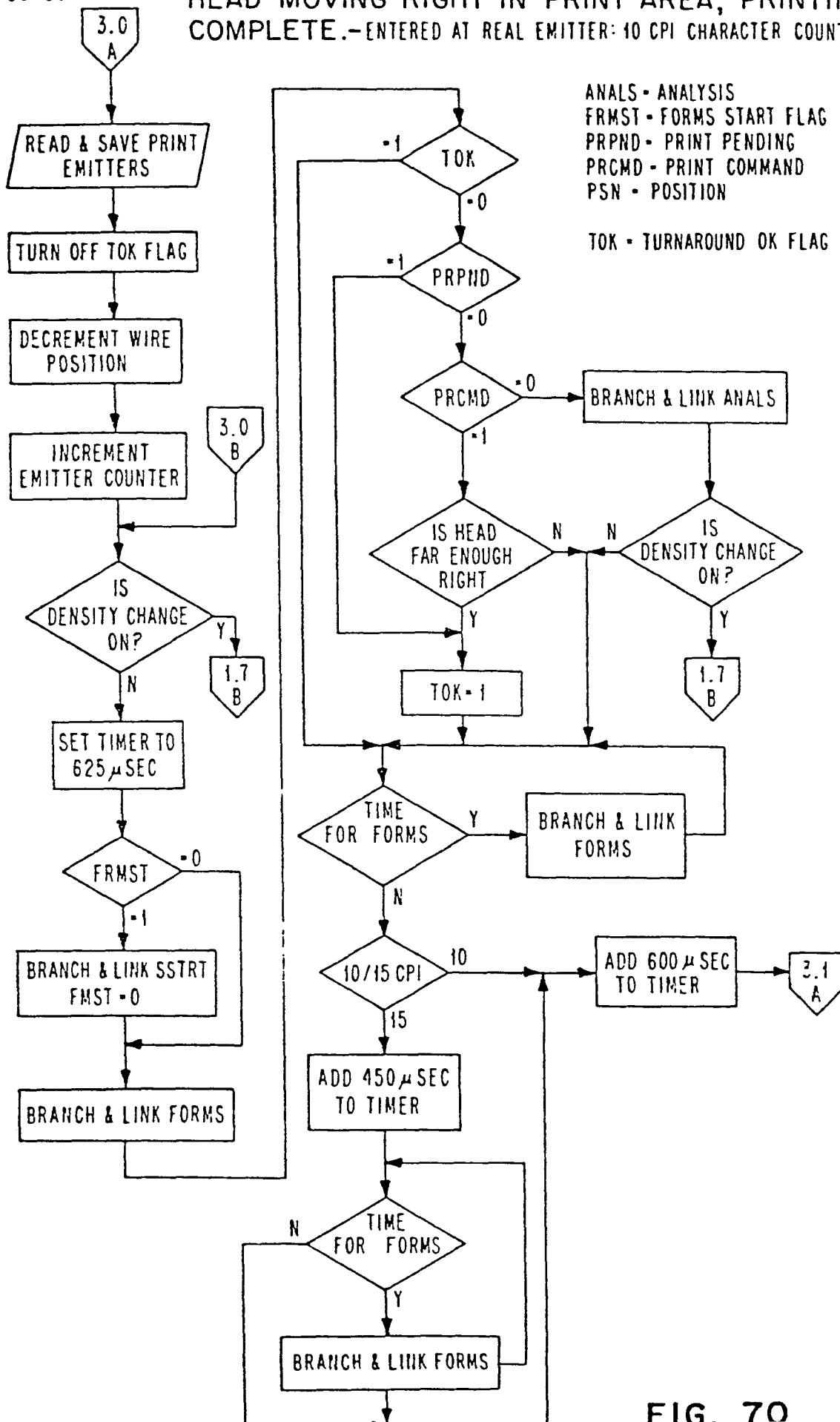


FIG. 70

HEAD MOVING RIGHT IN PRINT AREA, PRINTING COMPLETE

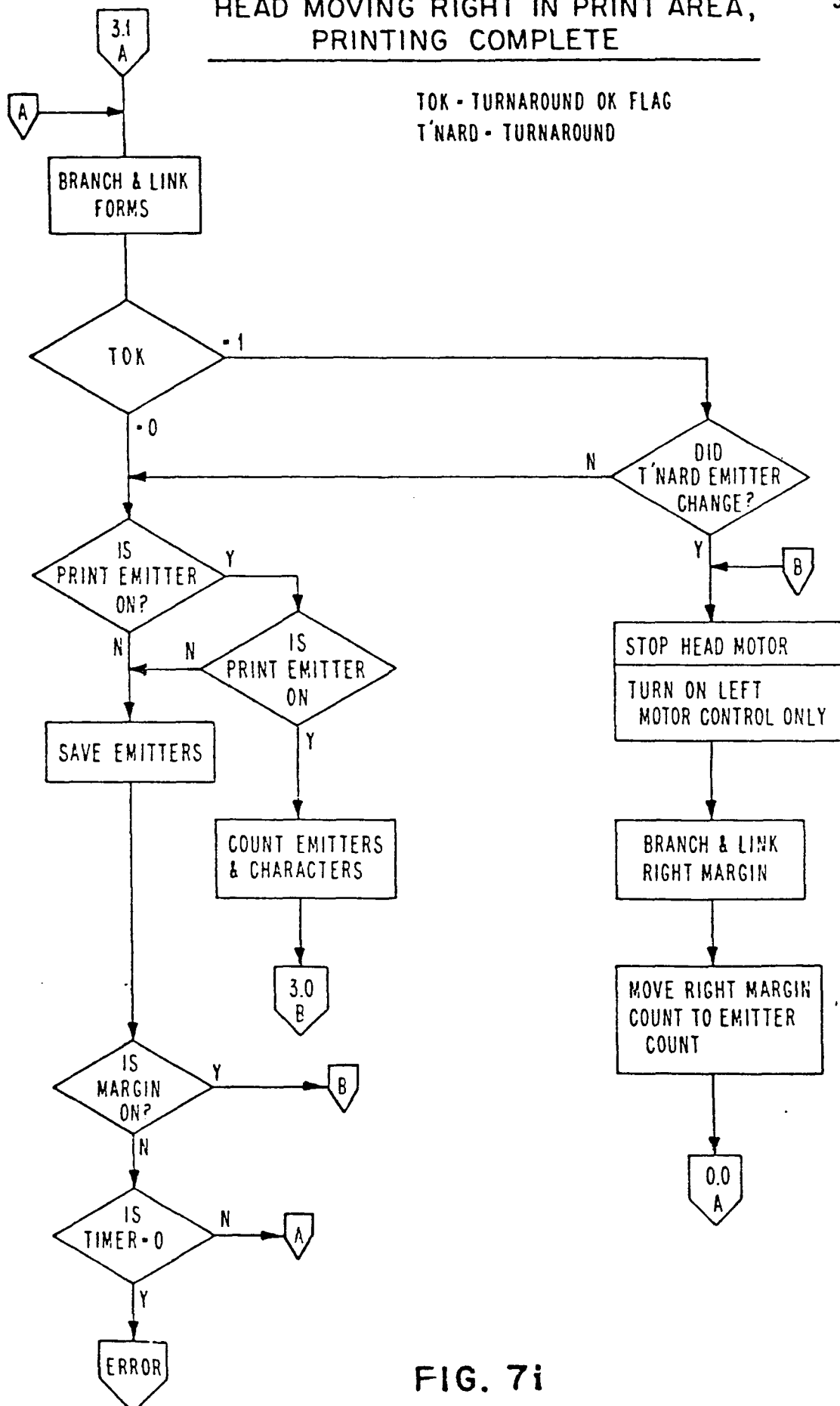


FIG. 7i

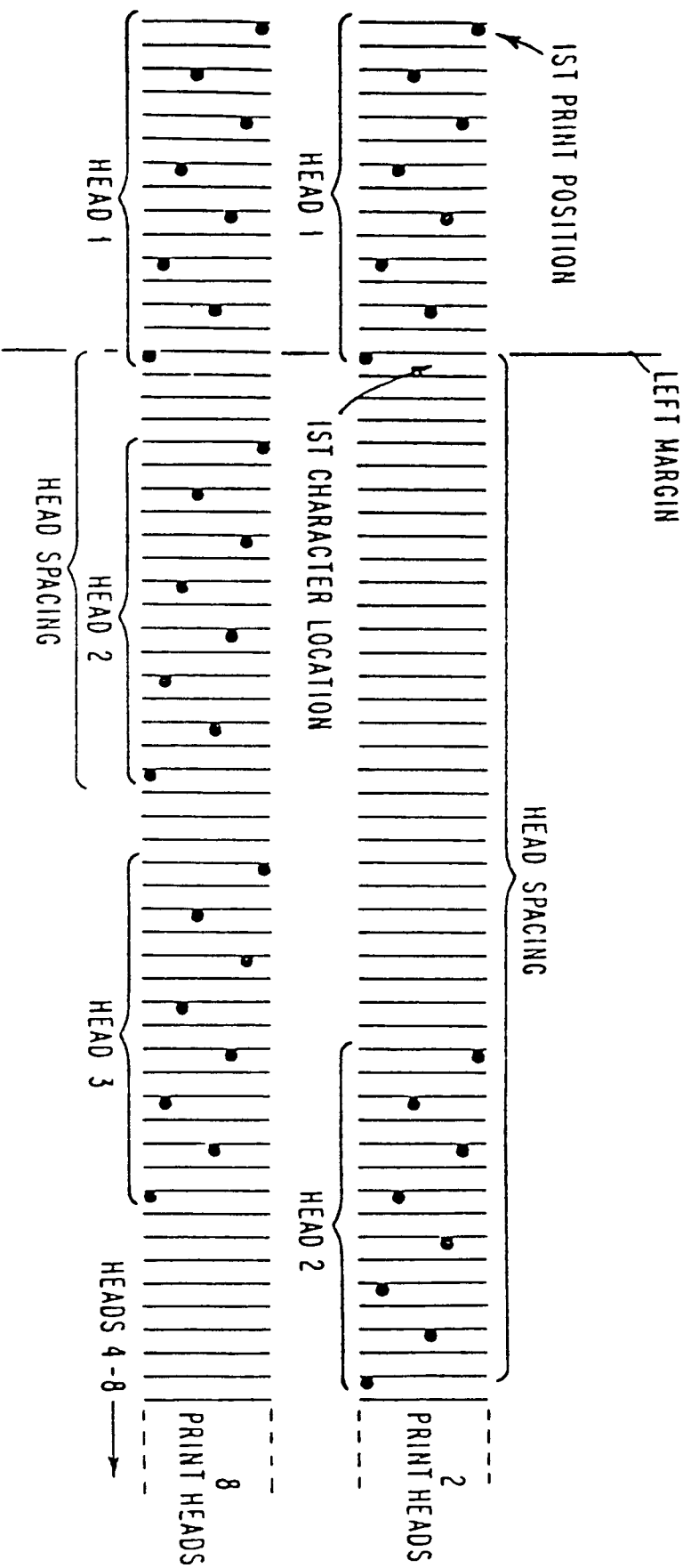


FIG. 72